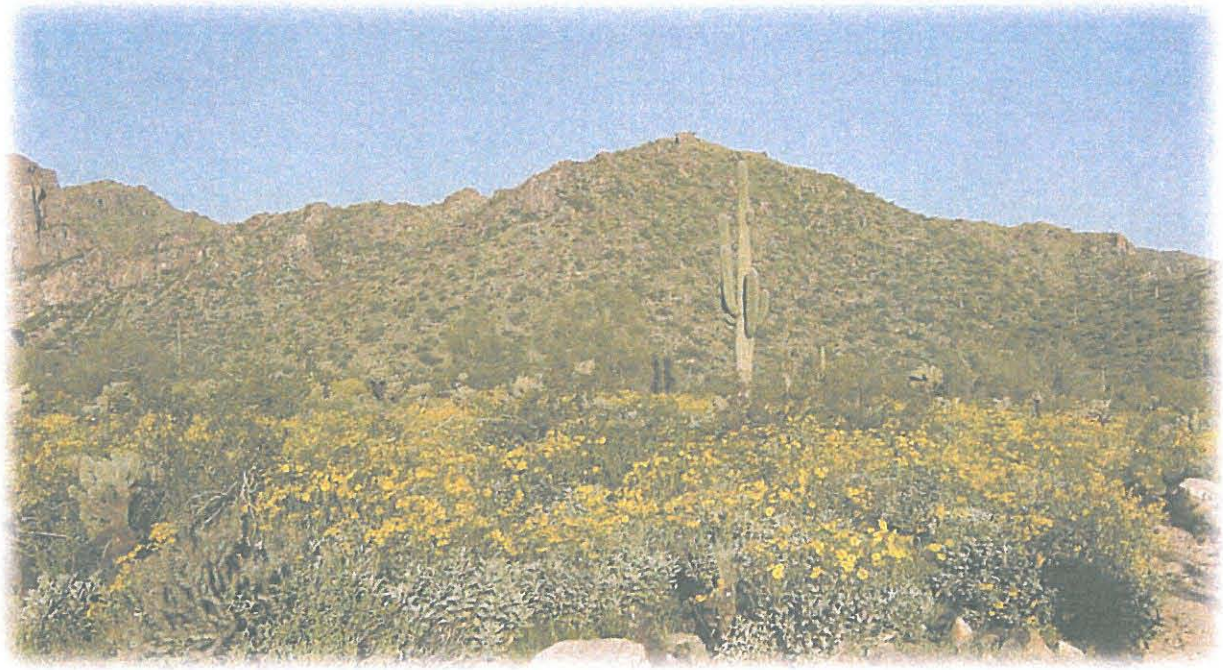

Final Hydrology Report

Loop 303/White Tanks ADMPU Area Hydrologic Analysis in Maricopa County, Arizona

Flood Control District of Maricopa County

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Expires 12/31/09

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FCD Contract No. 2007C031

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Abbreviations and Glossary:

AFB – Air Force Base

ADMP – Area Drainage Master Plan

ADMPU – Area Drainage Master Plan Update

ADMPU AHA – Area Drainage Master Plan Update Area Hydrologic Analysis

ADOT – Arizona Department of Transportation

ADWR – Arizona Department of Water Resources

Build Out – Land use condition that assumes complete development in a watershed according to applicable land use plans

CAR – Candidate Assessment Report

CIP – Capital Improvement Project (major drainage facility planned for construction, typically by public agencies)

DDMMC – Drainage Design Manual of Maricopa County

DDMSW – Drainage Design Management System for Windows (software program)

Discretized – divided into discrete segments

DU – dwelling unit

FCDMC – Flood Control District of Maricopa County

FEMA – Federal Emergency Management Agency

FIS – Flood Insurance Study

FRS – Flood Retarding Structure

GPS – Global Positioning System

HEC-1 – Hydraulic Engineering Center computer software program for hydrology

KM – "comment card" as an HEC-1 input

Kn – HEC-1 input parameter, estimated mean of all Manning's roughness coefficient values for the drainage pathways for the area

Loop 303 – State Route 303L highway

MAG – Maricopa Association of Governments

MB01 – Major Basin 01, the identifier given to the portion of the watershed generally located in the lower-elevation portions of the ADMPU AHA watershed.

MB02 – Major Basin 02, the identifier given to the portion of the watershed generally located in the White Tank mountains and draining to FRS #3 and #4.

NIC – North Inlet Channel

NOAA – National Oceanic and Atmospheric Administration (federal agency focused on the condition of the oceans and the atmosphere)

RID – Roosevelt Irrigation District

RTIMP – "percent impervious" as an HEC-1 input

Subbasin – portion of a watershed that drains to a common concentration point

USACE – United States Army Corps of Engineers

USGS – United States Geological Survey

1.0 EXECUTIVE SUMMARY

This report documents the hydrologic analysis performed as part of Contract FCD2007C031 for the Loop 303 / White Tanks Area Drainage Master Plan Update – Area Hydrologic Analysis (ADMPU AHA). The project is a joint project between the Flood Control District of Maricopa County (FCDMC) and the Arizona Department of Transportation (ADOT), administered by the FCDMC. ADOT and FCDMC recognized the potential benefits of coordinating the on-going SR303L drainage improvement design with this study for more accurate hydrology and a potential cost savings on drainage improvements.

Models were created for existing conditions as well as several different future land use and improvement scenarios in the watershed. These models will replace the prior ADMPU models completed by URS Corporation in June 2004 and become the effective models for the region. The purpose of the ADMPU AHA is to develop new hydrologic analyses to account for the development that has occurred in the area since the completion of the original update, include additional areas not covered in the previous work, and use updated mapping. These analyses also utilize NOAA 14 point rainfall depths and re-analyze split flow locations.

The Loop 303 / White Tanks ADMPU AHA study area is approximately 238 square miles and generally bounded by McMicken Dam on the north, the Agua Fria River on the east, the Gila River on the south, and the White Tank Mountain divide and Dean Road on the west.

The results indicate many differences between the previous models and these models. The differences are primarily due to updated methodology and approach over the previous models, primarily in loss coefficients and split flow calculations. Due to the differences in results between the previous model and this model, specific recommendations include:

- Investigate the effects of the new flow estimates in Bullard Wash.
- Examine Colter Channel for design capacity and flooding impacts based on the increased flow estimates.
- Modify the conceptual design of the Loop 303 drainage system based on the new estimates developed with this project.
- Investigate the areas of Bell Road near Reems Road and the area of Sun City West near RH Johnson Boulevard and Camino Del Sol for potential flooding.
- Tuthill Dike Wash near Interstate 10 has areas of potential split flows. These areas may benefit from additional detailed study.
- Several floodplains in the area may benefit from restudy.
- The new estimates of flows and volumes arriving to White Tanks #3 FRS are increased over the previous estimates. Although they appear to be within the capacity of the structure, further study may be warranted.

2.0 INTRODUCTION

This report documents the hydrologic analysis performed as part of Contract FCD2007C031 for the Loop 303 / White Tanks ADMPU AHA. This model will replace the prior ADMPU model completed by URS Corporation in June 2004. The purpose of the ADMPU AHA is to develop a new hydrologic analysis to account for the development that has occurred in the area since the completion of the original update, to include the area north of Grand Avenue not covered in the previous work, and use updated mapping. This analysis will also utilize NOAA Atlas 14 point rainfall depths and re-analyze all split flow locations.

The Loop 303 / White Tanks ADMPU AHA study area is approximately 238 square miles and generally bounded by McMicken Dam on the north, the Agua Fria River on the east, the Gila River on the south, and the White Tank Mountain divide and Dean Road on the west. **Figure 1 and 2.1** contains a Vicinity Map. The study area encompasses portions of major transportation corridors such as the Interstate 10 Freeway, Burlington Northern Santa Fe Railroad, Union Pacific Railroad, Grand Avenue (US 60), and the future Loop 303 Freeway and SR 801 Freeway. The study area encompasses major drainage ways and structures such as the Agua Fria River, Gila River, El Mirage Drain, Sun City Drains, Dysart Drain, Colter Channel, Beardsley Canal, White Tanks Flood Retarding Structure (FRS) #3 and White Tanks FRS #4. The study area includes portions of the following jurisdictions: Unincorporated Maricopa County, Arizona State Land Department, City of Avondale, Town of Buckeye, City of El Mirage, City of Glendale, City of Goodyear, City of Litchfield Park, City of Surprise, and Luke Air Force Base.

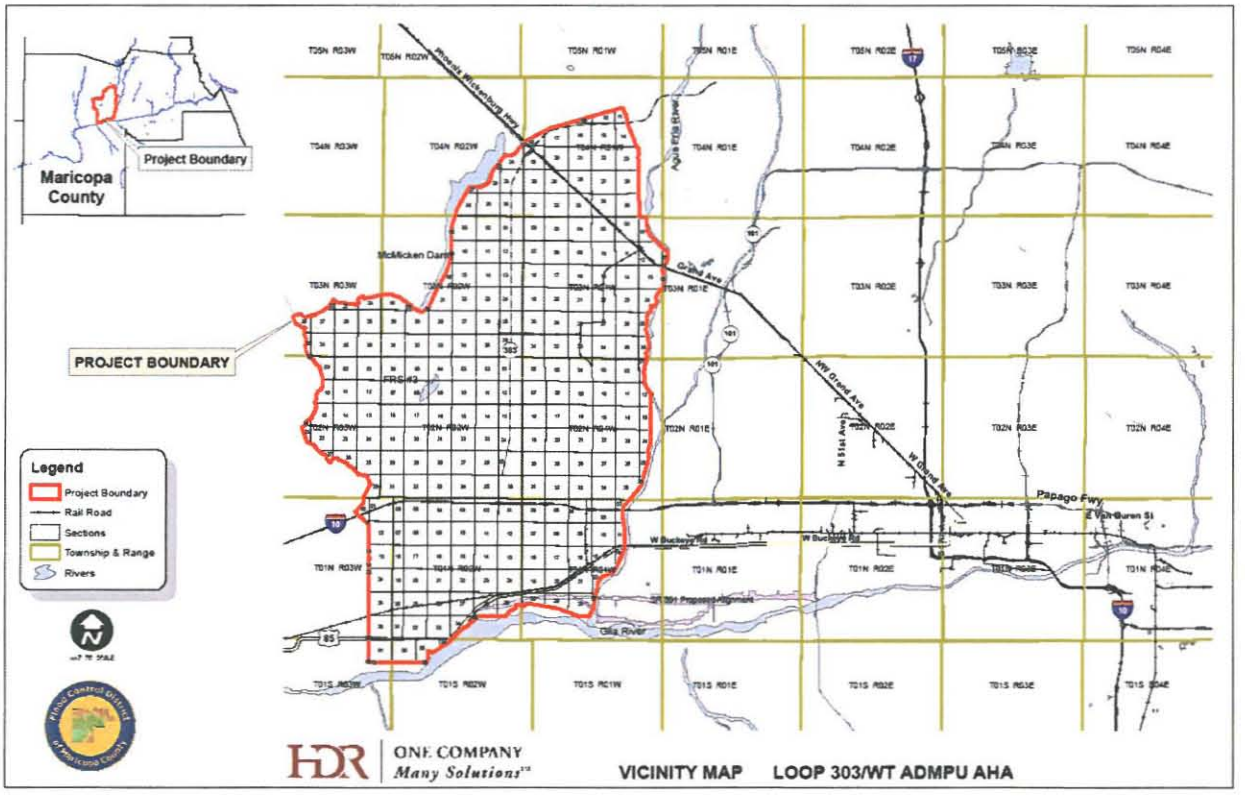


Figure 2.1 Vicinity Map

2.1 Data Collection Results

Extensive data collection occurred as part of this project, which included regional studies, design reports, and development reports. Data collection efforts are summarized in the Data Collection Memo, issued under separate cover on October 1, 2008. Some of the information and calculations used in this study were duplicated from earlier modeling efforts, such as the original WLB model and the updated URS model, both prepared for earlier versions of drainage master studies in the area. Additionally, several instances of calculations were duplicated from other engineering studies. The source of calculations can be found in the comments contained in the HEC-1 model and the sub-basin documentation appendices.

2.2 Existing Conditions

The watershed generally slopes to the south-southeast towards the Agua Fria River to the east and the Gila River to the south. Historically, the watershed was either undeveloped or used for agricultural purposes. However, the existing conditions of the watershed at the time of this study generally contain a mix of agricultural and residential master planned communities. The large watershed additionally encompasses many different municipalities, as shown in **Figure 2**.

Major existing drainage structures and improvements are located within the watershed, including the Dysart Drain, RID Canal Overchute and Siphon, Camelback Road Channel, Reems Road Channel, El Mirage Wash, Colter Channel, Bullard Wash, Agua Fria River Channelization, and White Tanks FRS #3 and #4. The Existing Facilities Map is attached as **Figure 3**. For the purposes of this project, an existing structure or feature is defined as one that exists or is under construction by June 1, 2008.

Additionally, the project was evaluated for planned capital improvement projects. For the purposes of this project, a capital improvement project (or CIP) is a major drainage facility planned for construction, typically by public agencies. Proposed subdivision and development plans were not considered. This includes the Tuthill Channel, Jackrabbit Channel, Northern Channel, Northern Parkway Drainage Improvements, Loop 303 Drainage Improvements, Reems Road Channel, AT&SF CAR improvements, Waddell CAR improvements, I-10 East and I-10 West diversion channels, and Bullard Wash improvements. A map of the CIP's are attached as **Figure 4**.

2.3 Future Conditions

Future conditions models were developed for the scenarios of with and without CIP's. The future conditions models were based on changes in land use, assuming complete development of the watershed according to planned land use (termed "build-out" conditions). The future conditions land use was determined from maps from the planning maps from the municipalities within the study area as well as the Maricopa Association of Governments (MAG). Further information on land use is contained in the Hydrologic Modeling Parameters section, below.

2.4 2017 Conditions

A model was created to approximate the conditions of the watershed in the year 2017. The 2017 model was developed to estimate the conditions that might exist along the new Loop 303 freeway

corridor in the year 2017, which is the estimated completion date of the freeway. The following assumptions were made:

- All drainage capital improvement projects in the upstream watershed will be constructed, including the Loop 303 system.
- Development will occur in the undeveloped land in the upstream watershed immediately adjacent to the west side of the freeway corridor. An estimate of 50% development was used; i.e. half of the currently undeveloped land within the subbasins along corridor will be developed according to the future land use plan. The subbasins subject to this assumption are shown on **Figure 12**.
- Retention according to the requirements of the governing agency was added to the newly developed land in the corridor. Calculated retention was based on the 100-year 2-hour retention requirement for all areas other than basins located within the City of Goodyear, where the 100-year 6-hour event was used. City of Goodyear requires that all new developments retain the 100-year 6-hour storm event. The "C" coefficient used for all new development was 0.95 and the intensity used was based on the NOAA Atlas 2 precipitation values since the date for regional adoption of NOAA Atlas 14 is unknown.
- The Lag and route lengths were not modified since it is not possible to determine where the new development will occur. This should result in a slightly more conservative peak flow.
- The S-Graph for the basins subject to development was modified to the Valley S-Graph, where it was previously using the agricultural S-graph.

2.5 Subsidence

The west valley area is subject to subsidence. The project area is part of the Western Metropolitan Phoenix feature mapped by the Arizona Department of Water Resources (ADWR). Land subsidence is generally due to compaction of the alluvium caused by lowering of the water table. This subsidence is generally not reversible.

Information obtained from previous reports during the data collection effort for this project indicates that the area near Camelback Road and Litchfield Road has experienced very little subsidence between the 1950's to 1980's, whereas the area near Olive Road and Reems Road has experienced significant subsidence, over 15 feet in the same time period.

ADWR has been using Synthetic Aperture Radar (SAR) and interferometric processing (InSAR) to detect land surface elevation changes and documenting them in maps. **Figure 2.5.1** contains subsidence in the project area for the time interval of 1992 to 2000. Additionally, a map was available for the period of 2004 to 2008, which is included in the appendices. A map was not available for 2000 to 2004. These maps indicated that localized areas within the project area may have seen several centimeters of subsidence within the time frames of the maps. However, this small amount of subsidence would not be enough to change regional drainage patterns. Subsidence is difficult to measure in areas that have undergone development. Therefore, a majority of the project area was unable to be measured using the InSAR methodology.

HDR attempted to locate structures that could be surveyed for a direct measurement of subsidence in the project area. In order to provide an accurate measurement, the structures must be tied to a bench mark that was not subject to subsidence, such as one set in competent rock. No definitive points were found that could be directly measured. Additionally, the amount of subsidence is anticipated based on the InSAR maps to be within normal field survey tolerances and therefore definitive results would not be obtainable.

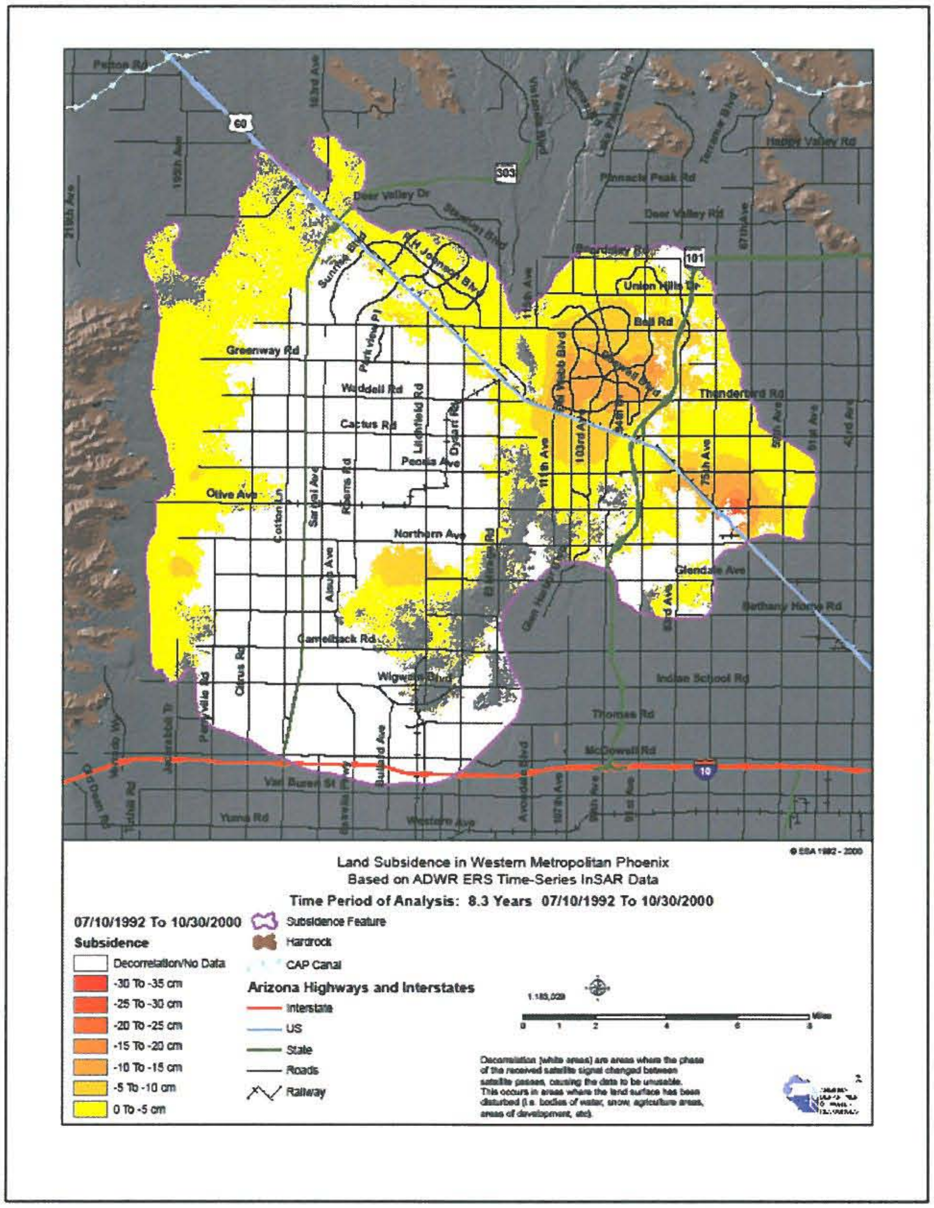


Figure 2.5.1 West Valley Subsidence (1992-2000)

3.0 HYDROLOGIC MODELING PARAMETERS

3.1 Methodology

Hydrology models were created to estimate runoff resulting from several different rainfall events, frequencies, land use, and improvement scenarios. The methodology generally follows the Drainage Design Manual for Maricopa County (DDMMC, November 2003 Draft). Any exceptions to the methodology are discussed below. The US Army Corps of Engineers' HEC-1 computer software program (version 4.1, June 1998) was used to perform calculations.

A Technical Approaches Memorandum was written for the project in June of 2008, which summarized the proposed technical approaches to the modeling effort. The following is a summary of the memo, including FCDMC comments.

1. *Precipitation – The watershed is divided into two distinct areas: subbasins generally located within the White Tank Mountains/foothills (the far western portion of the watershed), and all other subbasins, which are similar and located in milder terrain. The results indicate that precipitation estimate variability is generally low within each of the two regions. Therefore, a basin average precipitation value for each region will be used in the HEC-1 model. (Note: For localized design purposes, specific rainfall depth should be used for each basin)*

2. *S-graphs will be used and converted into unit hydrographs to perform the hydrologic routing. The Clark Unit Hydrograph will not be used as it has an upper watershed limit of 10 square miles.*

3. *Rainfall losses for each subbasin will be calculated using Green and Ampt. Channel transmission losses will be assumed to be zero in man-made and lined channels. Normal depth routing will be used in most routing reaches except for small man-made channels for little potential for flow attenuation where the kinematic wave method will be used.*

4. *Stock ponds and agricultural water quality storage basins will be assumed to be full in all storm events.*

5. *Canals, railroad embankments, and roadway embankments will be assumed to remain intact and functional during all storm events unless a reasonable expectation of failure exists. An example of a reasonable expectation of failure would be overtopping of an embankment during a storm event where the overtopping location was not specifically designed to carry such flows.*

6. *Conveyance from detention basin bleed pipes will be ignored for pipe sizes 24" in diameter and smaller. Basins will be assumed to be 80% effective, including underground retention.*

7. *The time step used will be 5 minutes and the number of ordinates will be 2000.*

8. *Areal Reduction: a sensitivity analysis will be performed on areal reduction as it relates to diversions in the model. The results of the sensitivity analysis may determine the methodology. (See Areal Reduction section, below)*

3.2 Model Descriptions

Models were created for the 100-year frequency (1% chance) storm, for the 2-hour, 6-hour, and 24-hour storm event. The 10-day duration event was originally part of the scope of work to determine volumes in the White Tanks structures, but was deleted by direction of the FCDMC. Flows larger than the 1% chance storm runoff can and do happen and are not analyzed as part of this project. Existing conditions are based on previously constructed or under construction items as of June 1, 2008.

Future conditions models were created with an estimate of future land usages (as described below in Section 3.5). A "2017" model was prepared to estimate the conditions that might exist along the new Loop 303 freeway corridor in the year 2017, which is the estimated completion date of the freeway. Additionally, both the existing and future land use models were run with and without regional improvement projects. **Figures 3 through 6** contain maps of existing facilities, proposed capital improvement project facilities, existing land use, and future land use. **Figure 12** contains "2017" land use conditions.

The area was divided into two models, Major Basin 01 and Major Basin 02. Several reasons for the division exist which are discussed throughout the report. Additionally, the HEC-1 model was initially created using the newest version of the District's Drainage Design Management System for Windows (DDMSW, Version 4.1.9). The software aids in creating HEC-1 files, and performs many calculations for the user, such as creating unit hydrographs, calculating NSTPS, and compositing land use parameter values.

3.3 Precipitation

NOAA Atlas 14 precipitation estimates were used in this model over the previous NOAA Atlas 2 estimates, which have historically been the precipitation estimates used by regulatory agencies in Maricopa County. NOAA Atlas 14 was released in 2004, which contains an additional 30 years of data over NOAA Atlas 2, issued in 1973.

Due to the large size of the watershed, it was unknown if precipitation estimates would vary significantly across the watershed. In order to determine the precipitation variability, numerous locations within the watershed were surveyed using NOAA Atlas 14 data. The watershed was divided into two distinct areas: subbasins generally located within the White Tank Mountains/foothills (the far western portion of the watershed, named Major Basin 02), and all other subbasins (Major Basin 01), which are similar and located in milder terrain. The results indicate that precipitation estimate variability is generally low within each of the two regions (reference the appendicies for numerical results). Therefore, a basin average precipitation value for each region was used in the HEC-1 model. The 100-year, 24-hour NOAA Atlas 14 average precipitation for the mountainous region is 3.941 inches, and 3.47 inches for all other subbasins.

However, due to limitations in the HEC-1 program, only one precipitation estimate can be used in the model. This would not differentiate between the mountainous region from the rest of the

model and would incorrectly give a value that is too low for the mountainous region and too high for the remainder of the basins. Therefore, the project was separated into two distinct models (Major Basin 01 and Major Basin 02) to allow for different precipitation in each basin.

3.4 Subbasin Delineation

Subbasin delineation was accomplished using the topographic sources described in Section 3.4.1, aerial photography, available reports, and field verification. In general, the target minimum subbasin size was 0.5 square miles and maximum subbasin size was 1 square mile. However, exceptions exist due to basin characteristics.

The watershed was divided into six regions with the following nomenclature: Northeast Region (N), White Tanks Region (W), Loop 303 Region (L), Dysart Region (D), Bullard Region (B) and Southwest Region (S). The subbasin ID's consist of the region letter followed by a number. This will make the sub-basins easier to find on a map or in the HEC-1 code. Subbasin boundaries are show for both "with" and "without" capital improvement projects in **Figures 9 and 10**.

3.4.1 Topographic Data Sources

Topographic sources are as follows. In general, 2-foot contour interval topo from 1990 was available for most of the watershed with the exception of the area to the north of Grand Avenue, where only 20-foot contour interval topography from 2001 was available. In some locations, additional detailed topography was available from development reports and design plans. These sources are described in detail in the *Data Collection Memo* prepared for this project, and summarized as:

- 2-foot contour interval for the entire project area (except the area north of Grand Avenue), by the FCDMC dated February of 1990;
- 20-foot contour interval for the entire project area, by USGS dated January 2001;
- 1-meter contour interval for Luke AFB, by Luke AFB dated 2003;
- 1-foot contour interval for the Loop 303 corridor, by ADOT dated 2001/2003;
- 1-foot contour interval for the I-10 corridor, by ADOT dated 2006;
- 2-foot contour interval for various spot areas (discussed further below), by FCDMC dated March 22, 2008;
- 2-foot contour interval for the area south of Lower Buckeye Road, by ADOT dated 2006.

As part of this project, aerial photography was performed for a majority of the project area using Airborne GPS on March 22, 2008. The area was flown at a 1"=200' mapping scale for a 2-foot contour interval mapping accuracy. Although the flight was performed, it was not the intent to map (i.e. extract topographic information) for the entire area flown. Rather, distinct limited areas were chosen for mapping. These areas included potential split flow locations, areas of substantial change from the 1990 mapping (not covered by

other topographic sources), and areas needing additional information to determine flow directions. Volumes 5 through 10 of this report contain hard copies of the topographic information obtained (sorted by area).

3.5 Land Use

Existing and future conditions land use was created for this project. Land Use maps are included as **Figures 5 and 6**. Existing conditions land use was created by visual inspection of the watershed, and summarized into general land use codes. Future conditions land use was created by obtaining planning maps from the municipalities within the watershed, as well as the Maricopa Association of Governments (MAG). The watershed was assumed to be in the "build out" condition for the future conditions models.

The land use codes used for this project generally follow the allowable land use codes found in the DDMMC and DDMSW program. These codes are summarized in Table 3.5.1, below.

Table 3.5.1 – Land Use Codes

Land Use	LUCODE	Land Use (Level 4 - Detailed)	Description	Kn	RTIMP
Single Family Low Density - Less than 1 du/ac	**110**	Rural Residential	<= 1/5 du* per acre (SF)	0.035	5
	120	Estate Residential	1/5 du per acre to 1 du per acre (SF)	0.035	5
Single Family Medium Density - 1 to 4 du/ac	**130**	Large Lot Residential (SF)	1 du per acre to 2 du per acre (SF)	0.035	15
	140	Medium Lot Residential (SF)	2-4 du per acre (SF)	0.032	25
Single Family High Density - Greater than 4 du/ac - Includes Mobile Homes	**150**	Small Lot Residential (SF)	4-6 du per acre (SF)	0.030	30
	160	Very Small Lot Residential (SF)	>6 du per acre (SF)	0.030	35
Multi Family	**170**	Medium Density Residential (MF)	5-10 du per acre (MF)	0.022	45
	180	High Density Residential (MF)	10-15 du per acre (MF)	0.022	45
	190	Very High Density Residential (MF)	>15 DU/AC Residential (MF)	0.025	45
Retail Low - Amusement/Movie Theatre/Specialty Retail/Neighborhood Retail	**200**	General Retail	Commercial where no detail available	0.025	80
	210	Specialty Commercial	<=50,000 square feet	0.022	80
	220	Neighborhood Commercial	50,000 to 100,000 square feet	0.022	80
Retail High - Community Retail/Regional Retail	**230**	Community Commercial	100,000 to 500,000 square feet	0.020	85
	240	Regional Commercial	500,000 to 1,000,000 square feet	0.020	85
	250	Super-Regional Commercial	>= 1,000,000 square feet	0.020	85
Industrial	**300**	General Industrial	General Industrial	0.020	55
	310	Light Industrial	Warehouse/Distribution Centers	0.020	55
	320	Industrial	Industrial	0.020	55

Table 3.5.1 – Land Use Codes (con't)

Land Use	LUCODE	Land Use (Level 4 - Detailed)	Description	Kn	RTIMP
Office	400	Office General	Office where no detail available	0.022	80
	410	Office Low Rise	1-4 stories	0.022	80
	420	Office Mid Rise	5-12 stories	0.025	85
	430	Office High Rise	13 stories or more	0.025	85
Other Employment - Landfill/Proving Grounds/Sand and Gravel/etc.	500	General Employment	Employment where no detail available	0.025	20
Tourist Accommodations - Motel/Hotel/Resort	510	Tourist and Visitor Accommodations	Hotels, motels and resorts	0.030	40
Education/Religious	520	Educational	Educational institutions where no detail available	0.030	50
Medical/Nursing Home	530	Institutional	Institutions where no details are available	0.030	50
Cemetery	540	Cemeteries	Cemeteries, Mausoleums, Crematoriums	0.028	10
Public/Special Event/Military	550	Public Facilities	Public Facilities where no details are available	0.030	25
	560	Special Events	Includes stadiums, sports complexes, and fairgrounds	0.030	50
Other Employment - Landfill/Proving Grounds/Sand and Gravel/etc.	570	Other Employment (low)	Other Employment (low)	0.025	40
	580	Other Employment (medium)	Other Employment (Medium)	0.025	40
	590	Other Employment (high)	Other Employment (High)	0.025	40
Transportation	600	General Transportation	Transportation where no detail available	0.018	95
	610	Transportation	Freeways/Expressways/ Highways/ Major Roads/ Arterials/ ROWs where no detail available	0.018	95
Airport	620	Airports	Public use airports	0.015	29**
Active Open Space	700	General Open Space	Open Space where no detail available	0.025	5
	710	City/Regional Active Open Space	Includes city/regional parks, playgrounds/fields	0.028	5
Golf Course	720	Golf courses	Golf Courses	0.030	5
Passive/Restricted Open Space	730	Passive Open Space	Includes mountain preserves and washes	0.030	0
Water	740	Water	Water	0.020	0
Agriculture	750	Agriculture	General Agriculture	0.100***	0****
Business Park	810	Business Park	Includes enclosed industrial, office or retail in a planned environment	0.025	80
Vacant	900	Vacant (existing land use database only)	Vacant	0.030/0.050(MB02 only)*****	0****

*du=dwelling unit
**Composite RTIMP developed based on Luke and Goodyear Airports. This RTIMP is only applicable for this area; larger airports would typically have a higher RTIMP value.
***Original Kn value of 0.150 was proposed; however, problems with UI card generation were solved by using 0.100
****Soils information may contribute additional RTIMP values. This is for land use parameters only.
*****Kn for vacant land within the mountains regions of Major Basin 02 is 0.050. MB01 is 0.030.

Kn, an estimated mean of all Manning's roughness coefficient values for the drainage pathways for the area, is calculated in this model based on the land use percentages for each subbasin. Additionally, the percent impervious is calculated similarly and based on land use percentages. These calculations are done automatically through the FCDMC's DDMSW software.

The Kn value was originally chosen at 0.150 for agricultural land. However, a problem with the UI card calculation in the DDMSW software caused the hydrograph to be truncated prematurely. In order to solve this problem, HDR was directed by the District to change the value to 0.100 which shortened the duration of the hydrograph in order to contain within the allowable UI cards. The Kn value for vacant land was different between the two major basins. Therefore, a higher Kn of 0.050 was used in the mountainous MB02 region. This helped to decrease flood wave velocities to more realistic values.

3.5.1 2017 Land Use

The 2017 model was created to estimate the conditions of the watershed in the year 2017 upstream of the Loop 303 drainage system. The model was created using the existing conditions land use with development adjacent to the west side of the Loop 303 corridor. **Figure 12** illustrates the 2017 Land Use.

3.5.2 Land Use Special Problems

3.5.2.1 Future Land Use

During the course of the project, it was discovered that the land use shown in the regional planning documents did not match existing land use types. The planned land uses were less dense than the existing land uses in many instances. While it is conceivable that localized areas are redeveloped, it is not likely that entire subdivisions would be torn down and replaced with subdivisions with lesser densities. It was recognized by the project team that this is a departure from the planning documents, but it is potentially more realistic. Therefore, future land use was created by using the existing land use, and only changing the land uses of 700, 750, and 900 to the future planned land use. **Figures 5 and 6** graphically show land uses used for the existing and future conditions models.

3.5.2.2 Verrado Area

It was discovered that a discrepancy existed between the regional MAG planning document and local planning document for the Verrado area for the MB02 watershed. Since the Verrado area is under development and an approved master plan community, a decision was made to use the local Verrado Development Plan to determine future land use.

3.5.2.3 WT FRS#3 Outfall Channel (Jackrabbit Trail) Area

Future land use differences exist between the design model for the White Tanks #3 FRS Outfall Channel (Jackrabbit Trail channel) and this model in the W21, W21A, W28 and W28A subbasins. The main difference is the assumption of the amount of development immediately adjacent to the White Tanks #3 Outfall channel. The land use in the "Future

with CIP" model associated with this project does not include a potential area of open space at the outfall. This is due to the source of the future land use data, which are the regional plans for the area. The land use plans do not indicate an area of open space, therefore one was not included.

Examples of both types of land use (open space versus complete development) directly below flood retarding structure outfalls can be found throughout the Phoenix metropolitan area. Therefore, either assumption could be considered valid. The assumption of complete development used in the future models in this project was chosen as it provides the most conservative result.

3.6 Soils

Soil characteristics were provided by the FCDMC for use on this project, and were derived from publications for the region by the USDA Soil Conservation Service. A summary of the land use for each subbasin is contained in the Figures and appendices. Agricultural land has different runoff characteristics than all other land uses. To model runoff from agricultural land, the following approach was used as summarized below in Table 3.6.1.

Table 3.6.1 – Agricultural Modeling Parameter Approach

Parameter	District Methodology Value
Flow Routing	Flow routed along roadways, until capacity is accounted for, then add the additional needed capacity from the adjacent fields.
Lag Time Equation (Kn)	0.06 < Kn < 0.15
IA	0.5 inch
DTHETA	Soils should be considered to be in a normal condition (not saturated)
PSIF	Varies, Use current District recommended values
XKSAT	Varies, Use current District recommended values
RTIMP	Use current District recommended values

3.6.1 Soil Characteristics Special Problems – RTIMP

The percent impervious (RTIMP) for each subbasin is calculated based on both soil and land use contributions to imperviousness. Impervious area may be comprised of rock outcrops, pavement, rooftops, etc. However, in the case of imperviousness associated with rock outcrops, the runoff from the outcrop must flow over pervious surfaces before reaching the associated concentration point. Therefore, if the rock outcrop is relatively small compared with the drainage area, is isolated from other impervious areas, and must travel through soils with relatively high infiltration capacities, an adjustment should be made.

This situation was discovered to exist in portions of the White Tank Mountains. The percent impervious for select subbasins was examined for potential adjustments under existing conditions, and the results are shown in Table 3.6.2. The following methodology was applied:

- Subbasins were examined for rock outcrops, and whether the outcrops were at the far end of the subbasin, flanking the sides of the subbasin, and proximity to direct connections (such as streets and pavement)

- The following reduction factors were applied: 75% reduction in rock RTIMP for location at the far end of the watershed, 50% reduction in rock RTIMP for rock flanking drainage pathways, and 25% reduction where outcrops had a closer connection to other impervious surfaces.

It is important to note that total RTIMP is calculated based on all impervious surfaces, and adjustments should only be made to rock outcropping percentages. Additionally, no adjustment was made in RTIMP values for future conditions, as development will occur and govern imperviousness in these basins.

Table 3.6.2 – Effective RTIMP Adjustments

Basin ID	Original RTIMP	Revised RTIMP	Notes
W04	21	10	Rock outcrops flanking drainage paths, 50% reduction
W12	5	3	Rock at far end of watershed. 75% reduction for rock (not for land use)
W13	5	3	Rock at far end of watershed. 75% reduction
W14	13	3	Rock at far end of watershed. 75% reduction
W18	17	8	Rock outcrops flanking, steep. 50% reduction
W19	20	No change	Topsoil stripped, grading, berms. Appears effective, no additional reduction
W25	15	8	Rock outcrops flanking drainage paths, 50% reduction
W43	61	No change	Soil borrow has exposed the bedrock.
W45	7	3	Rock outcrops flanking drainage paths, 50% reduction
W51	2	1	Rock at far end of watershed. 75% reduction
W52	17	9	Rock outcrops flanking drainage paths, 50% reduction
W53	11	7	RTIMP contribution from land use influences effectiveness. Rock outcrop now closer to drain path, most of RTIMP from land use, not rock. 25% reduction on rock RTIMP
W54	21	18	RTIMP contribution from land use influences effectiveness. Rock outcrop now closer to drain path, most of RTIMP from land use, not rock outcrop. 25% reduction on rock RTIMP

3.7 Routing

The routing of flow through the basins was estimated by preparing an 8 point cross section along the routing reach. Routing reaches were determined by using all topographic sources (as described above), aerial photography, available reports, and field verification. In many cases, specific data was not available and estimations were necessary. A GIS file was prepared and submitted as part of this project showing the routes used for both existing and future conditions.

3.7.1 Roughness Coefficients

Manning's roughness coefficients, or n-values, are used in the routing calculations. Up to three different values can be used in the eight point cross section (main channel and each overbank). N-values were chosen based on the existing or proposed channel material per Table 6.1 in the DDMMC, with some modifications. Engineering judgment was necessary in some cases to determine the appropriate channel material.

Table 3.7.1 – Roughness Coefficients

Channel Material	Value
Concrete	0.016
Soil Cement	0.020
Clean Earth, Straight	0.022
Earth with grass and forbs	0.025
Earth with sparse trees and shrubs	0.032
Shotcrete with earth bottom	0.022
Soil Cement with earth bottom	0.025
Concrete with earth bottom	0.020
Riprap with earth bottom	0.032
Natural desert wash with vegetation	0.035*
Semi-natural wash with vegetation	0.035*
Agricultural/cultivated earth	0.038
Natural desert wash with heavy vegetation	0.045

*increase to 0.040 for sheet or shallow flow

In localized instances, roughness coefficients deviate from the table above to ensure that routing results were within reasonable ranges. For instance, some of the steep slopes in the White Tank Mountains produced unreasonably high velocities using the roughness coefficients listed above, and therefore the n-values were increased to ensure reasonable flood wave velocities. These instances are documented in the comment cards in the HEC-1 model.

3.8 Storage

Several different types of storage exist within the study area. This includes local retention/detention basins, regional retention/detention basins, aggregate mining operations, and ponding behind elevated features (canals, railroad tracks and roadways). The ponding can occur due to undersized or non-existent drainage conveyance features such as culverts or bridges. As previously mentioned stock ponds and agricultural ponds are assumed to be full and disregarded in terms of storage.

Local retention/detention basin storage volumes were determined from drainage reports. If drainage reports were not available, the storage volume was estimated using aerial images. All retention basins were assumed to have 4:1 side slopes and be three feet deep. Storage calculations are summarized in the attachments.

In areas around Sun City in the northern portion of study area, a few drainage reports indicated design criteria instead of providing actual as built volumes. In these cases, retention volumes were calculated using NOAA 2 precipitation estimates (P=2.7 inches for 100-year, 2-hour event), as that was the governing precipitation estimate at the time development. The subbasins subject to these calculations are: D01, D02, D04 (only the Sun Village Portion), D06, D07, L01, and L02.

For future conditions, retention was calculated based the future land use and the standards of the regulating entity. The standard for retention within the project area is generally 100-year, 2-hour, with the exception of the City of Goodyear, which is 100-year, 6-hour. Additionally, the calculated retention was assumed at 80% effective.

3.9 Storage Investigation

Per the scope of the contract, storage volumes were compared to reported storage volume against actual as-built storage volume. Several drainage reports were pulled at random for subdivisions within the project area in order to determine reported volume. Twenty-five retention basins within five subdivisions were selected. The actual as-built volume was determined based on aerial photographs and field estimations. The results indicate that the as-built conditions either met or slightly exceeded the planned retention volumes. The results are contained in Volume 2 of the appendices.

3.10 Diversions and Flow Splits

One of the unique features of the study area is the presence of numerous flow splits. The majority of the flow splits occur at roadway intersections, where the elevated grades of the road govern the flow split characteristics. The project area was examined for potential flow splits, and the flow splits modeled in the previous ADMPU model were re-analyzed using the methodology discussed below.

3.10.1 Methodology

Two different types of flow split calculations were performed. These are termed "urban" and "weir" for ease of discussion, and are described in detail below.

- "Urban" flow split calculation methodology: This type of diversion tends to occur in urbanized areas, where a majority of the flow is carried within the street and right-of-way section. The street section tends to be lower in elevation than the surrounding improvements. The split that occurs is governed by the capacity of the downstream street sections.

- "Weir" flow split calculations methodology: This diversion is more common in the Loop 303/White Tanks basin, where the split flows are governed by an elevated feature that is modeled as a broad-crested weir, for calculation purposes. The improvements surrounding the feature tend to be lower in elevation, and some amount of ponding is expected behind the feature before the split occurs. (Major ponding behind an elevated feature is modeled with storage, as discussed above. Relatively minor ponding is disregarded.)

The weir flow split methodology has limitations in use for any other application other than this project. This is not a discretized (i.e., divided into discrete segments) weir calculation that would be balanced through iterations and therefore should not be used to determine actual flow amounts. The purpose of the calculation is to determine the percentage of flow in each direction to create a rating curve, not an actual flow amount. Caution should be exercised by the end user with this calculation methodology for any other use other than it was intended for on this project.

Instances of triple diversions exist in the watershed. Due to limitations in HEC-1 coding, a diverted flow cannot be retrieved then immediately diverted without error. Therefore, triple diverts must be coded such that both diversions must happen immediately after each other, and then retrieved later when needed.

3.10.2 Split Flow/Diversions Special Problems

3.10.2.1 Cotton Lane north of MC85/UPRR

A flow split is modeled in subbasin S21 that directs flow either east or west of Loop 303 to an existing drainage crossing of the UPRR tracks. However, the percentage of flow diversion is difficult to determine based on the unique conditions of the area, where all of the flow through the subbasin tends to be funned into the roadway section. Once in the roadway section, it will either split to the east or west as the capacity of the roadway section is exceeded. Therefore, an assumption that half of the flow goes each way was made for the purposes of this model.

This split may be important to the design of the future Loop 303 Drainage Channel, as the percentage of flow to the west at DS21SE will reach the proposed freeway channel. It may be prudent to design this future system with a more conservative assumption on the flow split than the 50-50 split used in this model.

3.11 Areal Reduction

Areal reduction is a major component in large watersheds such as this study area. The rainfall depths from the isopluvial maps in the DDMMC are point rainfalls for specified frequencies and durations. This is the depth of rainfall that is expected to occur at a point in a watershed for the

specified frequency and duration. However, this depth is not averaged to reflect the areal extents of the rainfall over the basin that would occur during a storm. This is because the intensity tends to decrease rapidly with increasing area in Maricopa County. A reduction factor is used to convert the point rainfall to an equivalent uniform depth of rainfall over the entire watershed.

For single storm simulations, the point rainfall is reduced according to the size of the watershed and introduced in the model as a fixed input parameter. When multiple storm simulations are performed, the area reduction is executed in HEC-1 using the JD records. The JD records allow for dynamic point rainfall corrections that occur at each sub-basin for which a flow hydrograph is generated.

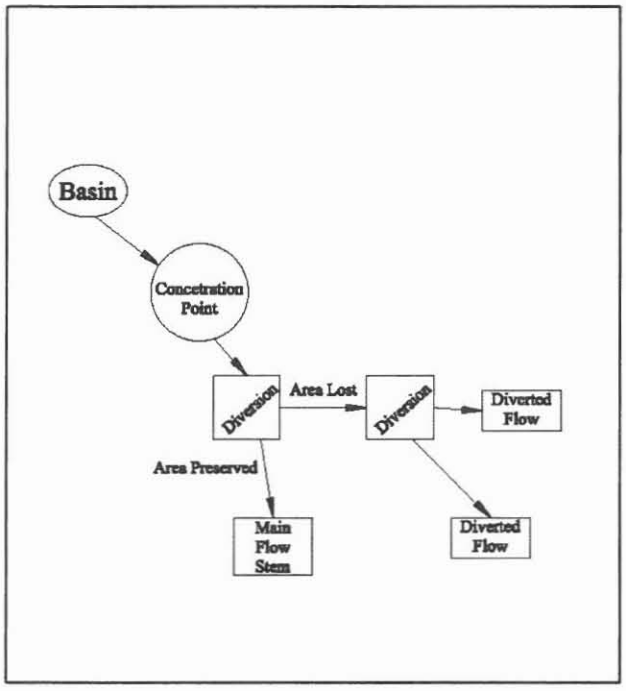


Figure 3.11.1 – Diversion Schematic

Application of areal reduction is particularly important in watersheds that have numerous flow diversions. In general, a flow diversion is modeled at a location where the inflow (described in the DI record) approaching a certain location (node) divides in two components (outflow and diversion) due to the topography or to the presence of hydraulic structures. The outflow component is the flow that continues on the same flow stem as the inflow, while the diversion component is the flow that is being diverted off the main flow stem and is described in the DQ record. Diversion simulations performed in a model using areal reduction encounter overestimated peak flows due to a "loss" of tributary area when hydrograph combines occur downstream of a diversion. The issue was corrected by manually introducing the cumulative tributary area in the second field of the hydrograph combine (HC) record.

The cumulative tributary area is determined by adding the subbasin areas upstream of the concentration point. Cumulative areas disregard diversions. In other words, the entire area is carried in both directions for the diversion and main stem because rainfall depth is reduced based on the drainage area; flow diversion percentages do not matter. Cumulative areas were calculated for each concentration point in order to avoid potential double-counting of areas where diverted flow recombines with the main stem.

3.11.1 Sensitivity Analysis

A sensitivity analysis was performed to determine if hard-coding of the upstream cumulative area could be avoided by setting up the HEC-1 tree in a certain order. The purpose of the Sensitivity Analysis was to determine the best approach for application of areal reduction in the watershed, taking several factors into consideration.

The "loss" of tributary area occurs because the flow diverted from the main flow stem does not "carry" the tributary area accumulated upstream of the diversion. Hence, at the location where the diverted flow is retrieved, the tributary area accumulated upstream of the hydrograph combine will not account for this upstream area associated with the retrieved flow.

From a modeling stand point at diversions, there are several aspects that must be considered:

1. The proportion of flow diverted with respect to the total inflow at that location;
2. Whether the diversion is retrieved back into the model or not;
3. The location where the diversion is retrieved back into the model; and
4. The character of the storm being modeled (local or general) and its recurrence interval.

The first aspect becomes very important, particularly when the diverted flow is a large fraction of the incoming flow. A general rule should be that the larger fraction of the flow stays on the main flow stem while the smaller fraction is diverted. However, there are situations where the split occurs in equal or close-to-equal fractions, and identifying the main flow stem is not intuitive. In such cases, the other aspects of split flow modeling should be considered and may determine how the split flow is set up.

The second aspect is intuitive and easy to determine; if a flow is completely diverted out of the model, there is no reason to be concerned with respect to areal reduction. This situation typically occurs at the fringes of the watershed, but it may also occur inside the watershed when a retention basin with no bleed-off line (or with a low-capacity bleed-off line) is being modeled. In these cases, no special modeling is necessary.

The third aspect refers to the most common situation where the diversion is retrieved back into the model. The location where the diversion is retrieved makes a difference with respect to whether the tributary area upstream is inclusive of the area associated with the divert or not. If the diversion is brought back into the same flow stem it departed from, there will be no need to consider the tributary area accumulated upstream, as the area was accounted for along the main flow stem.

If the diverted flow is retrieved on a different flow stem than the one it departed, further analysis is needed. The relative weight of the diverted flow with respect to the combined flow at the node downstream of the location of diversion retrieval should be considered. More importantly, the relative weight of the tributary area "lost" by the diversion and the cumulative tributary area on the flow stem where the diversion is retrieved must be evaluated.

If the flow stem cumulative tributary area is much larger (one or more orders of magnitude) than that "lost" by the diverted flow, the effect of not accounting the "lost" tributary area is negligible. However, if the situation is reversed and the "lost" tributary area is much larger than that of the flow stem, hard-coding an area correction in the HC record may be necessary. As previously mentioned, problems may arise during future use of a model that contains hard-coded information, as these are rarely examined and appropriately adjusted by future users that are unfamiliar with the unique conditions of the watershed.

The fourth aspect emphasizes that the magnitude of the flows generated by different types of storms is different. Such differences have an impact on the split ratio at certain diversions (street intersections, for example) that are sensitive to flow stage and flow direction. Under these conditions, hard-coding for a specific storm creates a fine-tuned model that does not have "dynamic flexibility" built in. Any changes in the model topology, particularly with respect to the split flow ratios would require hard-coding corrections downstream of these locations.

To maintain the end-user flexibility and the "dynamic ability" of the model to adapt, it is preferred to avoid hard-coding of areal corrections, and allow the areal associations to remain with the main flow stem. However, as discussed above, this may induce unacceptable errors. Therefore, this sensitivity analysis determines how sensitive the model is to different ways of approaching the split flow modeling.

The following methodology was followed:

1. Preparation of a hydrologic model for the test area. The test area was developed of 34 square miles within the 238 square mile watershed. The general flow direction is to the southeast, and flow splits tend to occur at intersections where some flow goes east and some to the south.
2. Reconfiguring of the hydrologic model to force a main flow stem ("East" and "South" models). The model described above was adapted into two non hard-coded models, each of them maintaining a consistent main flow stem direction (one east and one south) as far as flow split diversions are concerned. These models disregard the distribution of diverted flow; the main flow stem is forced to be always according to direction (either east or south), not according to flows. Therefore, in HEC-1, the main flow stem will maintain the reduction even if it is only a small percentage of the flow.
3. Reconfiguring of the hydrologic model to account for the main flow stem ("Main Flow" model. A third, non hard-coded hydrologic model was created that maintains a main flow stem according to the four modeling aspects discussed above in the special considerations section, for instance, examining the relative flow amounts at each diversion. For example, if 90% of the flow goes east and 10% of the flow goes south, then the eastern direction would be considered the main flow stem.
4. Adding hard-coded areal reduction ("Hard Coded" model). A fourth model was created based on the third model; this model will be hard-coded to maintain correct areal reduction and will be termed the "hard-coded base" model. It will be used as a basis of comparison for the results of the other models.

The models were run for two types of storms: a low recurrence local storm (100-year, 6-hour) and a low recurrence general storm (100-year, 24-hour). In all cases, the general storm yielded higher peak flows and was used as the basis for comparison.

3.11.1.1 Special Modeling Considerations

The initial models were created using actual watershed data. However, initial results indicated a few changes would result in a better sensitivity analysis. This included adding some split flow locations and removal of portions of retention in individual subbasins.

The addition of split flow locations was necessary to avoid recombines within the model. For example, the western portion of the model resulted in all of the flow diversions recombining at one location in the middle of the model, before appreciable area had been accumulated. Therefore, a few strategic splits were added to avoid having the diversion brought back into the same flow stem it departed from, which would negate the purpose of the sensitivity analysis.

Additionally, portions of retention were removed when a majority of flow was retained within the subbasin. This was done to avoid skewing the model results due to on-site retention versus true areal reduction. Please note that retention was not eliminated from subbasins, only adjusted to more realistic levels as defined by the volume calculation in the DDMMC using the 100-year, 2-hour rainfall depth.

3.11.1.2 Sensitivity Analysis Results

The four models, "East", "South", "Main Flow", and "Hard Coded" were created and simulated in HEC-1.

The sensitivity analysis resulted in differences of flows and cumulative areas based on the four modeling approaches. For example, the forced directional routing at concentration point CPD04 resulted in an almost 10 square mile cumulative area difference, and CPD30 had a difference of almost 17 square miles between two of the scenarios. Flow amounts generally remained within acceptable tolerances, with some exceptions (discussed below).

3.11.1.3 Sensitivity Analysis Original Recommendations

The results of the main stem flow model were within acceptable modeling tolerances, with the maximum deviation from the hard-coded model being less than 8% of the total flow amount. The "East" and "South" models have deviations above acceptable ranges, approaching 25% of the total flow amount. This was expected as previously described, and illustrates the importance of areal reduction considerations.

The original recommendation of the sensitivity analysis was for the Loop 303/White Tanks ADMPU AHA model to use the "main flow stem" method (as described above) for areal reduction, where the model is structured to follow the main flow stem but avoids hard-coding of areas in the model. However, during creation of the model, a unique problem occurred. This problem was dubbed the "competing main flow stem" phenomenon, where the number of flow splits caused two main flow stems to intersect. This caused the need for numerous DUMMY diverts and made the model extremely cumbersome. Additionally, concern was raised that the future users might be required to re-organize the entire model during minor revisions.

Therefore, the decision was made to manually introduce (or "hard-code") the upstream cumulative area into the HC record. Additionally, the FCDMC produced a beta-version software that reads HEC-1 files and provides the cumulative area at each concentration point. As of the date of this report, this software has not yet been released.

3.12 HEC-1 Schematic

In order to facilitate use of the model by others in the future, a HEC-1 schematic was generated for both "with" and "without" capital improvement projects. The schematic shows all operations of the model (basin, routing, storage, etc.) and how they relate to each other. The schematics are attached as **Figures 7 and 8**.

3.13 Capital Improvement Project Information

Information was obtained from the District, ADOT/PB, and numerous reports, preliminary design plans, models, etc. for future projects. The KM (comment) cards in the HEC-1 model document the source of each proposed improvement. Additionally, specific documentation exists in Volume 2 of this report. However, these designs are subject to change and should be evaluated for recent design changes before using the model for other purposes. In general, the sources for the CIP information reflected in the Existing with CIP and Future with CIP models are summarized in Table 3.13.1.

Table 3.13.1 – CIP Source Summary

CIP	Source
Loop 303 from Clearview to Camelback	"EX-SPLIT" HEC-1 model received on May 6, 2009 from PB.
Northern Channel	"EX-SPLIT" HEC-1 model received on May 6, 2009 from PB.
Loop 303 – Camelback area, Camelback to Bullard Wash	Camelback CAR dated August 15, 2008. "REC-EWP" HEC-1 model dated July 14, 2008.
Loop 303 from Camelback to McDowell Road	Camelback CAR dated August 15, 2008. "REC-EWP" HEC-1 model dated July 14, 2008.
Loop 303 from I-10 to Gila River	Loop 303 Drainage Improvements I-10 to Gila River CAR dated January 2008. "Alt_13_Future_Circular_Modified" HEC-1 model dated January 18, 2008.
I-10 Diversion Channel	"EX-SPLIT" HEC-1 model received on May 6, 2009 from PB.
Waddell Road and El Mirage Basin Improvements	Waddell Drainage Improvements CAR dated April 10, 2009. "RECPLANW" HEC-1 model dated April 2009.
AT&SF Channel	AT&SF Railroad Channel and Basin CAR, "ATSF" HEC-1 model dated February 6, 2009.
Northern Parkway Drainage Improvements	"AT&SF Railroad Channel and Basin CAR, "ATSF" HEC-1 model dated February 6, 2009.
Tuthill Channel (south of FRS 4)	Buckeye ADMP Conceptual Design Plans dated April 2009
Luke AFB drainage improvements	Luke AFB CAR dated October 2004.
Bullard Wash from Camelback to I-10	"L33PE4H9" HEC-1 model dated April 18, 2007
Bullard Wash from I-10 to Lower Buckeye	Bullard Wash Improvement I-10 to Phase 1 Proposed CLOMR HEC-RAS Model dated May 19, 2009.

4.0 RESULTS

Flow estimations were generated for existing conditions, as well as different scenarios of land use development and infrastructure construction. Electronic files associated with the results of this project are included in the appendices. Files include all HEC-1 input and output files, DDMSW files, CAD and GIS files, and spreadsheets. Table 4.1 below contains results of the models at specified locations. The results are discussed in additional detail in Sections 4.1 through 4.3 and Section 5.0.

Table 4.1 – Flow Comparison for 100-yr, 24-hr Event

Existing Conditions - No Projects				Existing Conditions - w/ CIP Projects						
HDR ID	URS ID	URS - 1/19/04 Peak Flow	HDR - 8/19/09 Peak Flow	HDR ID	URS ID	PB ID	URS - 1/19/04 Peak Flow	PB "Ex-Split" Peak Flow	HDR - 8/19/09 Peak Flow	Location
DL02RE	n/a	n/a	**906**	DL02RE	n/a	CP106	n/a	409	**891**	L303 atClearview
CPL05	CP113A	766	**386**	CPL05	n/a	!LP0	n/a	772	**636**	L303 at Bell
CPL09	CP121A	402	**10**	CPL09	n/a	!LP	n/a	818	**574**	L303 at Greenway
CPL13	CP131A	979	**443**	CPL13	n/a	!LP1	n/a	1234	**633**	L303 at Thunderbird
CPL19	CP145A	1318	**804**	CPL19	n/a	!LP2	n/a	2456	**1180**	L303 at Cactus
CPL27	CP164A	1765	**1118**	CPL27	n/a	!LP3	n/a	4018	**1735**	L303 at Peoria
CPL34	CP177A	493	**876**	CPL34B	n/a	!LP4	n/a	2005	**1242**	L303 at Olive
CPL39	CP192A	704	**777**	CPL39	n/a	!LP5	n/a	2082	**932**	L303 at Northern
CPL44	CP209A	1479	**985**	CPL44	n/a	!LP6	n/a	1758	**1570**	L303 at Glendale
CPL49	CP219	1083	**1016**	CPL49	n/a	!LP7	n/a	1943	**2208**	L303 at Bethany Home
CPL54	CP237	856	**1611**	CPL54	n/a	!LP8	n/a	2588	**2276**	L303 at Camelback
CPL58	CP250	693	**1790**	CPL58	n/a	!LP9	n/a	652	**967**	L303 at Indian School
CPL64	CP265	507	**582**	CPL64	n/a	!LP10	n/a	700	**994**	L303 at Thomas
CPL68	CP278	1348	**663**	CPL68	n/a	!LP11	n/a	1416	**1306**	L303 at McDowell
CPL72	n/a	n/a	**668**	CPL72	n/a	ILP12	n/a	2383	**2078**	L303 at I-10 (NW)
n/a	n/a	n/a	**n/a**	SRL72	n/a	SRLP12	n/a	483	**383**	L303 at I-10 (SW)
CPS13	CP295	625	**680**	CPS13	n/a	!LP13	n/a	526	**599**	L303 at Van Buren
CPS19	CP311	611	**205**	CPS19	!LP14	n/a	659	n/a	**236**	L303 at Yuma
CPS20	CP330	1108	**299**	CPS20	!LP15	n/a	676	n/a	**628**	L303 at Lower Buckeye
CPS26	CP346C	980	**415**	CPS26	CP346C	n/a	116	n/a	**663**	L303 at UPRR
L10	129	339	**845**	L10	129	n/a	N/A	n/a	**845**	Thunderbird at Citrus
CPD19	CP133	1005	**583**	CPD19	!RM2	n/a	957	n/a	**416**	Reems Road at Thunderbird Road
CPD25	CP138A	453	**204**	CPD25	CP138A	n/a	115	n/a	**309**	Waddell at Dysart
CPD72	CP195	1360	**724**	CPD72	!!C195	n/a	1722	n/a	**458**	AT&SF at Northern
CPB57	CP241	2376	**2355**	CPB57	n/a	n/a	N/A	n/a	**2671**	Bullard Wash at Camelback Road
CPB15	CP245	1132	**2450**	CPB15	!!C245	n/a	1132	n/a	**2450**	Colter Channel at Agua Fria River
CPB58	CP267	2557	**2352**	CPB58	n/a	n/a	N/A	n/a	**2684**	Bullard Wash at Thomas Road
CPW20	CPWT3	7618	**8098**	CPW20	!!WT3	n/a	9847	n/a	**8089**	FRS #3
CPS60	CPWT4	6896	**6461**	CPS60	!!WT4	n/a	6833	n/a	**6609**	FRS #4
CPS21	CP346A	1075	**828**	CPS21	!LP16	n/a	751	n/a	**n/a**	Cotton north of Lower Buckeye
CPS77	CP349	873	**567**	CPS77	CP349	n/a	867	n/a	**748**	UPRR near Dean Road
CPS80	CP379	1466	**1280**	CPS80	CP379	n/a	1619	n/a	**895**	Boundary at Suzy Dean Ditch and Dean Rd

Table 4.1 – Flow Comparison for 100-yr, 24-hr Event (con't)

Future Conditions - No Projects				Future Conditions - w/ CIP Projects						
HDR ID	URS ID	URS - 1/19/04 Peak Flow	HDR - 8/19/09 Peak Flow	HDR ID	URS ID	PB ID	URS - 1/19/04 Peak Flow	PB "Ex-Split" Peak Flow	HDR - 8/19/09 Peak Flow	Location
DL02RE	n/a	n/a	**906**	DL02RE	n/a	CP106	n/a	n/a	**891**	L303 atClearview
CPL05	CP113A	544	**386**	CPL05	n/a	!LP0	n/a	n/a	**636**	L303 at Bell
CPL09	CP121A	353	**6**	CPL09	n/a	!LP	n/a	n/a	**574**	L303 at Greenway
CPL13	CP131A	634	**312**	CPL13	n/a	!LP1	n/a	n/a	**505**	L303 at Thunderbird
CPL19	CP145A	619	**467**	CPL19	n/a	!LP2	n/a	n/a	**511**	L303 at Cactus
CPL27	CP164A	764	**433**	CPL27	n/a	!LP3	n/a	n/a	**518**	L303 at Peoria
CPL34	CP177A	230	**622**	CPL34B	n/a	!LP4	n/a	n/a	**517**	L303 at Olive
CPL39	CP192A	227	**201**	CPL39	n/a	!LP5	n/a	n/a	**488**	L303 at Northern
CPL44	CP209A	833	**905**	CPL44	n/a	!LP6	n/a	n/a	**1122**	L303 at Glendale
CPL49	CP219	821	**844**	CPL49	n/a	!LP7	n/a	n/a	**1530**	L303 at Bethany Home
CPL54	CP237	607	**1038**	CPL54	n/a	!LP8	n/a	n/a	**1476**	L303 at Camelback
CPL58	CP250	292	**736**	CPL58	n/a	!LP9	n/a	n/a	**305**	L303 at Indian School
CPL64	CP265	244	**147**	CPL64	n/a	!LP10	n/a	n/a	**322**	L303 at Thomas
CPL68	CP278	740	**1079**	CPL68	n/a	!LP11	n/a	n/a	**1158**	L303 at McDowell
CPL72	n/a	n/a	**1097**	CPL72	n/a	ILP12	n/a	n/a	**1621**	L303 at I-10 (NW)
SRL72	n/a	n/a	**n/a**	SRL72	n/a	SRLP12	n/a	n/a	**185**	L303 at I-10 (SW)
CPS13	CP295	419	**277**	CPS13	n/a	!LP13	n/a	n/a	**197**	L303 at Van Buren
CPS19	CP311	427	**17**	CPS19	!LP14	n/a	93	n/a	**199**	L303 at Yuma
CPS20	CP330	469	**12**	CPS20	!LP15	n/a	293	n/a	**209**	L303 at Lower Buckeye
CPS26	CP346C	481	**142**	CPS26	CP346C	n/a	39	n/a	**209**	L303 at UPRR
L10	129	339	**845**	L10	129	n/a	N/A	n/a	**845**	Thunderbird at Citrus
CPD19	CP133	828	**521**	CPD19	!RM2	n/a	699	n/a	**437**	Reems Road at Thunderbird Road
CPD25	CP138A	237	**39**	CPD25	CP138A	n/a	115	n/a	**69**	Waddell at Dysart
CPD72	CP195	1099	**322**	CPD72	!!C195	n/a	1296	n/a	**258**	AT&SF at Northern
CPB57	CP241	2453	**1732**	CPB57	n/a	n/a	N/A	n/a	**1633**	Bullard Wash at Camelback Road
CPB15	CP245	648	**1705**	CPB15	!!C245	n/a	648	n/a	**1707**	Colter Channel at Agua Fria River
CPB58	CP267	2171	**1652**	CPB58	n/a	n/a	N/A	n/a	**1563**	Bullard Wash at Thomas Road
CPW20	CPWT3	7461	**8751**	CPW20	!!WT3	n/a	9549	n/a	**8637**	FRS #3
CPS60	CPWT4	3560	**5052**	CPS60	!!WT4	n/a	3486	n/a	**4621**	FRS #4
CPS21	CP346A	466	**311**	CPS21	!LP16	n/a	300	n/a	**n/a**	Cotton north of Lower Buckeye
CPS77	CP349	542	**851**	CPS77	CP349	n/a	542	n/a	**687**	UPRR near Dean Road
CPS80	CP379	563	**337**	CPS80	CP379	n/a	2843	n/a	**449**	Boundary at Suzy Dean Ditch and Dean Rd

4.1 Existing Conditions Results

Existing conditions models were generated for the 100-year (1% chance) frequency at the 24-, 6-, and 2-hour durations for existing conditions and existing conditions with capital improvement projects in place. HEC-1 input and output printouts are contained in Volumes 3 and 4 of this study.

A comparison was made between the results of this project with the previous effective models and three sources of envelope curves: USGS, Malvick, and Boughton (source reference of the curves can be found in the DDMSW and DDMMC). The results are shown in **Figures 4.1.1 through 4.1.3**, below.

Examinations of the results indicate that the results are reasonably consistent with previous studies, and fall within the envelope curves of the USGS and Boughton comparisons. Results compared to the Malvick curve show general agreement, although flows are not completely contained beneath the envelope curve. However, the Malvick study was completed in 1980 and the results are considered out-of-date when compared to more recent studies.

The curves below contain all subbasins and are not filtered for the effects of diversions and retention. Therefore, the basins that show very low or zero discharge are due to diversions and retention and should be disregarded.

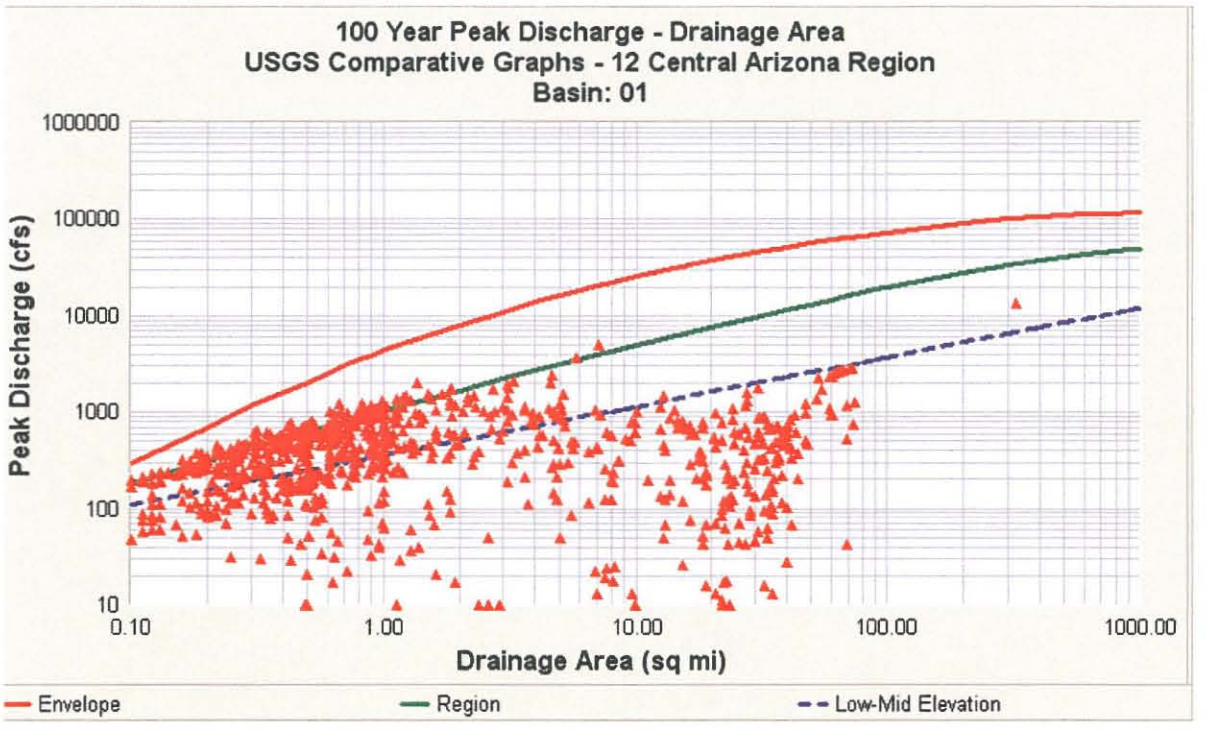


Figure 4.1.1 – Regional Discharge Curve Comparison (USGS)

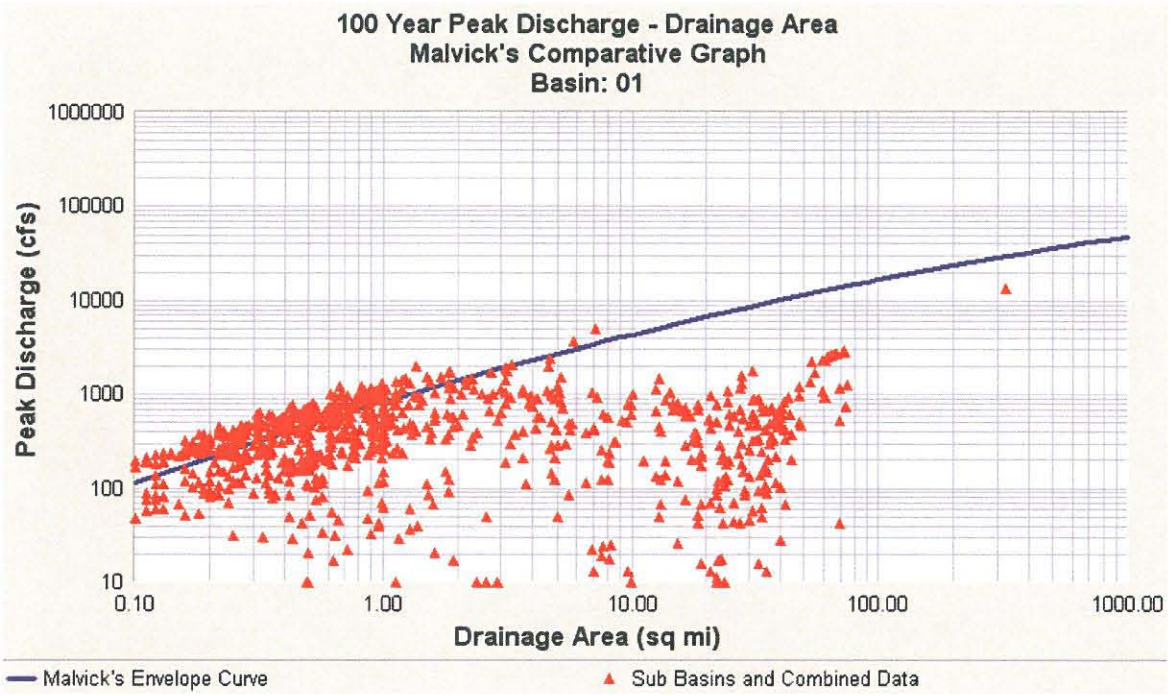


Figure 4.1.2 – Regional Discharge Curve Comparison (Malvick)

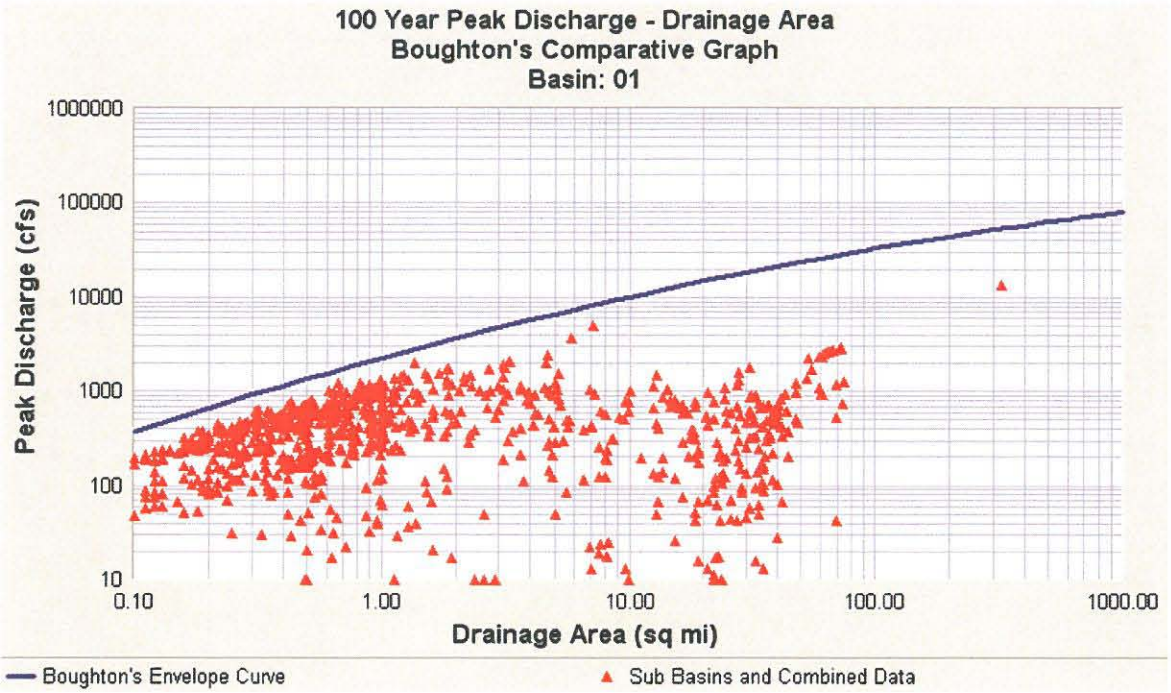


Figure 4.1.3 – Regional Discharge Curve Comparison (Boughton)

4.2 Future Conditions Results

Future conditions models were generated for the 100-year (1% chance) frequency at the 24-, 6-, and 2-hour durations for future conditions and future conditions with capital improvement projects in place. HEC-1 input and output is contained in Volumes 3 and 4 of this study.

Future conditions have generally lower peak flows than existing conditions for the basins that will undergo development in the future. This is due to the retention requirements placed on future developments.

4.3 2017 Conditions Results

The results indicate peak flows along the freeway corridor are slightly lower than existing conditions, with one exception. The exception is located at CPL49 at the Loop 303 and Bethany Home Road intersection. This flow increased by 41 cfs over existing conditions, due to the increase in flow from subbasin L49, which had 162 cfs generated under existing conditions, and 415 cfs generated under 2017 conditions.

As the corridor develops, routing attenuation and retention may function differently than modeled, and simplifying assumptions were made for the purposes of this project. However, these assumptions are considered conservative for the case of partial build-out of the subbasins along the Loop 303 corridor.

5.0 RECOMMENDATIONS/DISCUSSIONS

Comparisons were made between the flows predicted by the 2005 URS Loop 303/White Tanks ADMPU, revisions to the URS ADMPU, and the flows predicted by this project. The models used for comparison were:

- URS's "L303FB8" – Future Conditions
- URS's "L303MIL" – Existing Conditions
- URS's "L33PE4H" – Existing Conditions with Projects in Place
- URS's "L33PF6D" – Future Conditions with Projects in Place
- PB/ADOT's "Ex-Split" – Existing Conditions with the Loop 303 project in place (only for comparisons along the Loop 303 corridor)

Differences were examined for potential revisions in floodplain delineations, or the potential need for improvements. General differences can be explained as follows:

- The parameters of IA, DTHETA, and RTIMP are different in this model than the previous models, some of which pre-dated the publication of the DDMMC. All coefficients used in this model are within the ranges specified in the DDMMC. The model was found to be particularly sensitive to the RTIMP parameter.
- The flow splits developed for this project differed in most locations from the previous flow split estimates. Changes are primarily due to development in the area, but additionally can be attributed to calculation methodology differences and better topographic data in localized areas.
- Development in the watershed has caused two opposing effects: increased retention and decreased attenuation due to channelization.

5.1 Discussion at Locations of Interest

The results of the models at locations of interest were compared against existing capacities, results, or models. The source of comparison is listed in **Table 5.1.1**, below. The locations for additional discussion were determined through meetings with FCDMC and ADOT, and generally consist of existing and future drainage infrastructure. Figures 3 and 4 contain graphical depictions of the locations of these items.

Table 5.1.1 – Facilities Flow Comparisons

System Name (Report Section Reference)		Location	ID from source	Design capacity (cfs) or (ac-ft)	HDR ID (Location)	ADMPU AHA results Exist w/ CIP (cfs) or (ac-ft)	Comparison Data Source
ADOT Basins (5.1.1)	*I-10 at Litchfield Road*	West basin	n/a	28 acft**	SRB73	**12 ac-ft**	2005 URS basin modeling
		Basin west of Litchfield	n/a	117 acft**	SRB74	**46 ac-ft**	
		Basin east of Litchfield	n/a	479 acft**	SRB84	**133 ac-ft**	
		East basin	n/a	219 acft**	SRB83	**17 ac-ft**	
AT&SF (5.1.2)	*AT&SF and Northern Pkwy systems*	Cactus at RR Tracks	!RR3	388	CPD40	**215**	"ATSF.out"
		Peoria at RR Tracks	!RR4	583	CPD49	**724**	
		Railroad curve	!RR5	805	CPD63	**752**	
		Olive at Dysart Road	!RR6	543	CPD64	**293**	
		Northern Pkwy at Dysart Road	!RR7	633	CPD74	**316**	
		After Northern Pkwy Basin	2RR7	504	CPD78A	**263**	
		Olive at RR Tracks	CP181	239	CPD61	**105**	
		Northern Pkwy at RR Tracks	!C195B	521	CPD72A	**327**	
Bullard Wash (5.1.3)	*Camelback to I-10*	Bullard Wash at Camelback	n/a	n/a	CPB54	**2867**	Palm Valley Ph 5 Rpt, EEC
		Bullard Wash at Indian School	n/a	2780	CPB57	**2671**	
		Bullard Wash at Thomas	n/a	2495	CPB58	**2684**	
		Bullard Wash at McDowell	n/a	2640	CPB59	**2863**	
		Bullard Wash Detention Basins - between I-10 and McDowell Rd	!BD4N	3248	CPB65A	**3883**	Wood Patel L33PE4H9
	I-10 to Lower Buckeye	Bullard Wash, after basin at I-10	n/a	3200	CPB65B	**1885**	Wood/Patel rpt FCD 2001C023
		Bullard Wash at Van Buren	n/a	3200	CPB66	**1996**	
		Bullard Wash at Yuma	n/a	3200	CPB68	**2101**	
		Bullard Wash at Lower Buckeye	n/a	3200	CPB69	**2141**	
	Lower Buckeye to River	Bullard Wash at UPRR	C1	3200	CPB70	**2275**	Design Data from FCDMC
		Bullard Wash at Broadway	A3	3200	CPB93	**2330**	
		Bullard Wash at River	A2	3200	CPB94	**2327**	
Colter Channel (5.1.5)	*Dysart to River*	Colter Channel at Dysart	n/a	1060	CPB11	**1190**	Wood Patel Rpt 11/92
		Colter Channel btwn Dysart and El Mirage	n/a	1080	CPB12	**1501**	
		Colter Channel at El Mirage	n/a	1210	CPB14	**1936**	
		Colter Channel at AF River	n/a	1210	CPB15	**2450**	

Table 5.1.1 – Facilities Flow Comparisons (con't)

System Name (Report Section Reference)		Location	ID from source	Design capacity (cfs) or (ac-ft)	HDR ID (Location)	ADMPU AHA results Exist w/ CIP (cfs) or (ac-ft)	Comparison Data Source
Dysart Drain (5.1.6)	*Falcon Dunes to El Mirage*	Flow into Falcon Dunes	CP193	596	CPD70	**748**	Dysart Drain Improv. Project Rpt 1994
		Storage at Falcon Dunes	n/a	407.9 ac-ft	SRD70	**147 ac-ft**	
		Dysart Drain at Bullard Ave	CP194	448	CPD71	**267**	
		Dysart Drain at old RR crossing	CP195	1772	CPD72	**458**	
		Dysart Drain at Litchfield Road	CP196	2300	CPD73	**573**	
		Dysart Drain at Dysart Road	CP202	2287	CPD78B	**1062**	
		Dysart Drain at El Mirage	CP204	3984	CPD79B	**1197**	
I-10 West Diversion Channel (5.1.7)	*191st to L303*	I-10 at 191st Ave	!10W1	970	CPW32	**575**	EX_SPLT model from PB, May 6, 2009
		I-10 at Perryville	!10W2	1010	CPL65	**1048**	
		I-10 at Citrus	!10W5	1596	CPL71	**1179**	
Loop 303 System (5.1.8)	*Clearview to UPRR*	L303 atClearview	CP106	409	DL02RE	**891**	EX_SPLT model from PB, May 6, 2009
		L303 at Bell	!LP0	772	CPL05	**636**	
		L303 at Greenway	!LP	818	CPL09	**574**	
		L303 at Thunderbird	!LP1	1234	CPL13	**633**	
		L303 at Cactus	!LP2	2456	CPL19	**1180**	
		L303 at Peoria	!LP3	4018	CPL27	**1735**	
		L303 at Olive	!LP4	2005	CPL34B	**1242**	
		L303 at Northern	!LP5	2082	CPL39	**932**	
		L303 at Glendale	!LP6	1758	CPL44	**1570**	
		L303 at Bethany Home	!LP7	1943	CPL49	**2208**	
		L303 at Camelback	!LP8	2588	CPL54	**2276**	
		L303 at Indian School	!LP9	652	CPL58	**967**	
		L303 at Thomas	!LP10	700	CPL64	**994**	
		L303 at McDowell	!LP11	1416	CPL68	**1306**	
		L303 at I-10 (NW)	!LP12	2383	CPL72	**2078**	
		L303 at I-10 (SW)	SRLP12	483	SRL72	**383**	
		L303 at Van Buren	!LP13	526	CPS13	**599**	
		L303 at Yuma	!LP14	659	CPS19	**236**	
		L303 at Lower Buckeye	!LP15	676	CPS20	**628**	
		L303 at UPRR	CP346C	116	CPS26	**663**	

Table 5.1.1 – Facilities Flow Comparisons (con't)

System Name (Report Section Reference)		Location	ID from source	Design capacity (cfs) or (ac-ft)	HDR ID (Location)	ADMPU AHA results Exist w/ CIP (cfs) or (ac-ft)	Comparison Data Source
Reems Road Channel (5.1.9)	*Bell to Olive*	Reems Road at Bell	CP115	513	CPD02	**617**	EC_RMS.OUT 5/5/05
		Reems at Greenway	CP122A	911	CPD10	**637**	
		Reems at TB/Waddell	CP133	1005	CPD19	**416**	
		Reems at Cactus	CP146	2498	CPD30	**712**	
		Reems at Peoria	CP165	2881	CPD46	**735**	
		Reems at Olive	CP179	2557	CPD58	**700**	
RID (5.1.10)		RID Overchute Project	n/a	1456	CPB76A	**773**	Design Report
W. Cactus Basin (5.1.12)		El Mirage Basin (West Cactus Basin)	!LE4	881	CPD53	**355**	RECPLANW.OUT
Waddell CAR		Waddell at Litchfiled	CP137	431	CPD23	**130**	RECPLANW.OUT
		Waddell at Dysart	CP138A	209	CPD25	**309**	
WT #3 North Inlet Channel (5.1.13)	*Olive to Glendale*	NIC at Olive	CP3	2715	CPW05	**2514**	Plans 2005C019
		NIC - west split at Olive	CP10	5679	W0512A	**989*****	L303M3LA.OUT, 11/10/06
		NIC - east split at Olive	SIDWR	1600	W0512B	**1461**	
		NIC at Northern	CP10B	7131	CPW12	**5628**	Plans 2007C021
		NIC at Glendale	CP12	7567	CPW13	**6062**	
WT #3 (5.1.14)		White Tanks FRS #3	CPWT3	7618	CPW20	**8089**	URS Exist w/ CIP model L33PE4H.OH1
			CPWT3	901	SRW20	**1370 ac-ft**	
White Tanks FRS #3 Outfall (5.1.15)	*FRS#3 to I-10*	Jackrabbit below FRS#3	CPW21A	560	CPW21A	**100***	Hoskin-Ryan 30% Rpt #3 Outfall chnl
		Jackrabbit above Camelback Road	CPW28A	700	CPW28A	**630***	
		Jackrabbit above Indian School Road 1/2 mi	CPW33	800	CPW33	**942***	
		Jackrabbit at Indian School Road	CPW35	700	CPW35	**773***	
		Jackrabbit at Thomas Road	CPW36	700	CPW36	**812***	
		Jackrabbit at I-10	CPW38	1549	CPW37	**1103***	
WT #4 Inlet Channel		White Tanks FRS #4 at I-10	n/a	2206	W37S60	**1721**	LOMR
WT#4 (5.1.16)		White Tanks FRS #4	CPWT4	6896	CPS60	**6609**	URS Exist w/ CIP model L33PE4H
			CPWT4	767 ac-ft	SRS60	**729 ac-ft**	
WT #4 Outlet Channel (5.1.17)	*Yuma to UPRR*	Tuthill at Yuma	n/a	353	CPS64	**1369**	Buckeye ADMP plans dated 2009
		Tuthill at Lower Buckeye	n/a	1452	CPS68	**1489**	
		Tuthill at Broadway	n/a	898	CPS69	**1501**	
		Tuthill at UPRR	n/a	781	CPS70	**1651**	

*=Future w/ CIP, **=Previous calculated volume, no design available, ***=Does not include flows from Cholla Wash

5.1.1 ADOT Detention Basins, I-10 near Litchfield Road

Large basins exist immediately adjacent to I-10 between Dysart Road and Bullard Avenue. These basins provide regional stormwater detention, but were not desinged for a specific runoff event (the volume was based on needed fill material for the freeway construction). The basins are interconnected via culverts and drain directly to the Agua Fria River in a storm drain system.

Due to the limitations of HEC-1, some simplifying assumptions are made on the basin function and arrival of flow. Therefore, further work would be necessary to more accurately determine basin storage characteristics and function. Additional detail on modeling of the basins can be found in the previous 2005 Loop 303/White Tanks ADMPU project.

5.1.2 AT&SF Basin and Channel System

The AT&SF basin and channel system is a proposed capital improvement project to alleviate flooding along the AT&SF railroad tracks. The proposed design for the AT&SF drainage improvements (AT&SF CAR model, dated 2008) were added to the CIP models.

The flows in the system were generally less in this model than the AT&SF CAR model, which was expected due to the lower rainfall amount and retention from development. However, the one exception is the flow at CPD49 (Peoria Road at the railroad tracks), which is slightly higher. This increase is due to flow contribution from subbasin D49 (called subbasin 168A and 168B in the CAR model). This subbasin is the site of the City of Surprise wastewater treatment plant. The CAR model has a lower RTIMP and higher retention amount, which would explain the lower flow contribution from the subbasin. The ADMPU AHA models assumed that the treatment ponds would be full. This is a conservative assumption, while valid for most pond situations, may not be valid for wastewater treatment plants. This depends on the operating level of the ponds and potential for additional storage of water above the operating level. If additional storage exists in an amount that exceeds the volume of the storm event, then it may be valid to increase the retention amount and decrease the RTIMP, similar to the CAR model parameters. Additional detailed investigation into the assumptions for RTIMP and retention may be warranted prior to final design of the system.

5.1.3 Bullard Wash

Bullard Wash originates at Luke AFB (upper watershed limit formed by Dysart Drain) and flows south to the Gila River. The flows into Bullard Wash are shown to be higher in some locations and lower in other locations under existing conditions than the previous ADMPU model.

One significant source is the increased percent impervious from the two airports (Luke Air Force Base and Goodyear Airport) that contribute runoff into Bullard Wash. The previous model had 15% impervious at Luke AFB and 13% impervious at

Goodyear Airport. However, improvements have occurred to the airfields and these percentages were determined to be too low compared to existing conditions.

The methodology applied in this study for calculating imperviousness was to determine an average percent impervious by land use type. The FCDMC provided the impervious percentage using estimates created from aerial photography of the Luke AFB and Goodyear Airport. An average of 29% was developed for the airports in this watershed. This may seem too low compared to larger commercial type airports, which tend to have very high RTIMP values. However, the amount of pavement at these airports was found to be less than typical since neither handles commercial passenger traffic. However, any future updates to this model should carefully examine the airports for further development and the potential for additional impervious area.

A difference in flow exists in Bullard Wash between Camelback and Indian School Road, due to improvements that were constructed along Camelback Road. The improvements were designed to prevent split flows across Camelback Road between Loop 303 and Bullard Wash. Therefore, more flow is now directed towards the segment of Bullard Wash between Camelback Road and Indian School Road.

The flow increases over the previous ADMPU model in Bullard Wash carry through the system until just north of I-10. At this point, the retention provided by development negates the additional amount from the increased upstream imperviousness. South of I-10, the flows remain below the design capacity of the channel of 3,200 cfs. As development occurs in the future, the additional retention in the watershed will continue to decrease flow contribution in the channel.

5.1.4 Cholla Wash

Cholla Wash is a natural wash that originates in the White Tanks Mountains, and has a relatively steep and rocky watershed. Cholla Wash enters the White Tanks #3 inlet channel in subbasin W12 as route W11W12. The effective Federal Emergency Management Agency (FEMA) flows of 3,816 cfs as listed in Maricopa County's Flood Insurance Study (FIS) were originally based on the 1991 WLB model. Due to simplifications in this model, a separate concentration point was not developed that isolates Cholla Wash flows from the Beardsley Canal flows, therefore no direct comparison can be made. However, if a direct comparison is warranted in the future, modifications can be made in the model to develop a separate concentration point for the wash.

5.1.5 Colter Channel

Flows into the Colter Channel have been influenced by development. Per a previous development agreement, direct discharge was allowed into the channel. The limiting distance away from the channel where direct discharge would be prohibited was not available. However, a large retention basin (the former Murphy Dam site) does exist within the watershed but appears to be underutilized, and most of the B11 watershed drains directly into the channel.

Additionally, the contribution of the runoff from subbasin B13 north of Bethany Home Road, which was previously shown to drain east, drains to the Colter Channel. This adds 0.5 square miles to the watershed. Although the previous model had this area draining to the east, recent development has channelized this flow to the south and a berm exists along the length of El Mirage Road that prevents flow to the east.

The soil borrow/mining activities occurring in subbasins B06 and B15 may be providing retention that is not reflected in this model. Therefore, further work may be necessary to accurately quantify the flow shown to reach the Colter Channel from these two sources.

The flows shown in the channel are higher than the 1992 design flows. The channel should be examined for actual available capacity. Should additional capacity be necessary, it may be possible to convey flows (via storm drain or other method) into the underutilized basins in the watershed to reduce flows to the channel.

5.1.6 Dysart Drain

Dysart Drain is a regional channel located to the north of Luke Air Force Base. The channel receives flow from the north and conveys it to the Agua Fria River to the east. The design flows for the channel are greater than shown by this model. This is expected as improvement projects and developments have occurred in the upstream watershed and provided retention since the channel was designed.

A simplifying assumption was made in this model for flow contribution along the channel. In many locations, the flow will enter the channel via sheet flow; however, a point concentration of flow may be assumed in the model. This occurs at the upstream-most point of contribution to be conservative. For example, flow enters the Dysart Drain between Bullard Avenue and the old railroad alignment via sheet flow from the agricultural fields to the north. Although the model indicates that the flow will enter the channel as a point concentration at CPD71, the flow contribution from the north is expected to enter the channel somewhere between CPD71 and CPD72 as sheet flow. The channel design accommodates this sheet flow via a depressed weir along this reach.

Additionally, the flow contribution into Dysart Drain at Dysart Road (CPD78) is different when compared to previous models (although still less than the original design discharge). This is due to changes in the model upstream of the Drain, where an increased flow amount occurs over the railroad tracks at D63. Additionally, the removal of a split flow upstream at Olive and Dysart (D64) directs more flow to the south.

5.1.7 I-10 West Diversion Channel

The I-10 West Diversion Channel is a proposed channel immediately north of Interstate 10 from approximately Jackrabbit Trail to Loop 303, and is proposed to drain into the Loop 303 basin and channel system. Flows arriving at the diversion channel are generally slightly lower or similar to the previous design model flows,

which can be attributed to the lower precipitation from NOAA Atlas 14 estimates over the previous NOAA Atlas 2 estimates.

5.1.8 Loop 303 System

The drainage system associated with the Loop 303 freeway has been conceptually designed using the 2005 ADMPU model. The proposed design as of March 2009 was placed in the CIP models; however, it is intended that the design will be updated based on the results of this project. Therefore, certain components of the system may be shown to be above or below capacity in the "with CIP" models associated with this project, which should be disregarded as it was beyond the scope of this project to modify the design of the future improvements.

In general, flow arrival to the Loop 303 drainage system is different in this project compared to previous models. Although generally lower flow and volume amounts arrive into the system, the distribution is different. This can be attributed to the re-analyzing of all upstream flow splits, and differences in the watershed due to development.

Specific differences include:

- Lower precipitation estimates from NOAA Atlas 14.
- At the upstream portion of the drainage system north of Bell Road, a large amount of temporary retention included in the earlier models no longer exists due to development.
- Development in the northern portion of the watershed reduced flows with the addition of retention.
- The Cortessa development (subbasins L30, L31, and L36) reduced flows with the addition of retention.
- Development changes at Indian School and Citrus Road changes the flow split characteristics to convey more flow to the east and less to the south.
- Drainage improvements in the White Tanks mountains (MB02) watershed removes previous flow breakouts. The White Tanks FRS #3 North Inlet Channel improvements constructed a parallel channel that conveys flow to FRS #3 that previously entered the MB01 watershed.
- The former flow split at Greenway Road (L06) was removed due to development improvements.

5.1.9 Reems Road Channel

The Reems Road channel and basin system flows are generally less than the previous design model. The one exception is the segment of the channel between Bell Road and Greenway Road, where the flows are slightly more than the design

flows. This is due to the addition of flows that overtop the basin at Sunrise Boulevard and Bell Road (CPD06). Sunrise Boulevard is elevated and prevents any flow to the east.

The previous model had all flows going southeast and entering the channel at Greenway Road. However, field examination indicated that once the capacity of the basin is exceeded, the flows will enter the Bell Road street section and travel east, with the diversion to the southeast occurring only after the capacity of the street is exceeded. The contribution of the street flow into the channel on the west side of Reems Road is the reason for the increase over the previous model.

The flows are generally lower throughout the system due to the addition of retention in the watershed and differences in the upstream flow splits, which were re-analyzed as part of this project. The previous model had all flows along the Loop 303 corridor routed to the east between Greenway Road and Northern Avenue, thus adding more flow into the Reems Road system. Flow splits were modeled at these locations under existing conditions.

Additionally, after the Loop 303 drainage and roadway improvements are completed, all flows upstream of the Loop 303 corridor will be intercepted by that system. The freeway will form the new upper limit of the Reems Road watershed, which will provide an additional decrease in the flows reaching the channel.

5.1.10 RID Overchute

The RID Overchute is a drainage improvement that allows flow over the RID irrigation channel in the Litchfield Park area. The flows arriving at the RID overchute are lower in this model compared with previous models. However, numerous assumptions exist in this area, particularly in subbasin delineation and routes. Even though there appears to be excess capacity at the RID crossing, a more detailed study of this area is warranted to determine actual flows arriving at the overchute.

5.1.11 Tuthill Dike Wash

The flows from the Verrado Master Plan community generally drain into the Tuthill Dike Wash, located along the Tuthill Road corridor. The flows drain to box culverts under Interstate 10 and ultimately to FRS#4. Although the capacity of the culverts is large enough to handle expected flows under extreme head conditions, flows are arriving at the box culverts under I-10 are expected to overtop the berm and travel east along the freeway corridor.

Immediately downstream and adjacent to the berm is a large 12-foot by 12-foot vehicle underpass that could theoretically pass flow to the south. However, field inspections reveal that the underpass would only pass flow after significant head has developed. Upstream conditions are not contained, and a significant depth of ponding upstream of the culvert is not likely. Therefore, the conveyance associated with this vehicle underpass is ignored.

Figure 5.1.11.1 – Tuthill Dike Wash berm

As flow breaks out to the east past the vehicle underpass, it can be conveyed under I-10 through numerous small culverts, and some amount of ponding is expected due to undulations in existing grades.

Additionally, during field visits conducted in August of 2009, an interruption of the berm was observed along Tuthill Dike Wash. This interruption appears to have been created by the construction of a power pole. Further investigation into the downstream impacts is recommended.

5.1.12 West Cactus Basin - Lower El Mirage Wash

The West Cactus Basin, located in subbasin D53, is a detention basin that outfalls into the Lower El Mirage Wash at El Mirage Road. The outflow into Lower El Mirage Wash is lower than the previous models. The reasons for this are the increased retention in the upper portion of the watershed due to development (particularly subbasin D14), and instances of storage occurring the wash upstream of the basin. The storage occurs at Waddell Road (D27) due to a culvert crossing of the roadway and at Cactus Road (D42) due to an elevated roadway crossing that allows storage in the channel prior to overtopping the roadway.

Improvements are planned at the Cactus Road crossing as detailed in the Waddell CAR. These improvements were carefully designed to maintain the storage in the wash upstream of the basin, and any final design should additionally maintain the storage to prevent increasing the flows downstream.

5.1.13 White Tanks FRS #3 North Inlet Channel

The White Tanks #3 North Inlet Channel (NIC) ensures that flows from the White Tank Mountains watershed are directed to FRS #3. A recent improvement project eliminated breakout flows to the east by constructing a parallel channel between Olive and Northern Avenues. The parallel channel was designed for 1600 cfs.

Flows are generally slightly less in the NIC system in the current model versus the design model. This is due to the decreased precipitation and updated loss parameters in the upstream watershed.

5.1.14 White Tanks FRS #3 Flood Retarding Structure

Flows into the White Tanks FRS #3 are slightly higher than the previous model. The increase is seen in both peak flow arriving at the structure and the volume of flow. The models were examined against the previous ADMPU model to determine the

differences, since development was minor was not the likely cause of the differences.

The ADMPU AHA models have higher rainfall excesses than the previous models. Loss parameters were examined, with the major difference being the AHA models with higher percent imperviousness (RTIMP values). This explains the increases seen at the structure. The RTIMPs were examined during the course of the project and adjusted lower where they may not be fully effective (as discussed in Section 3.6.1, above); however, they remain higher than the previous models. Other differences that are less significant include minor differences in DTHETA, and a slight increase in overall watershed area drainage to the structure.

5.1.15 White Tanks FRS #3 Outfall Channel (Jackrabbit Trail Channel)

The design of the White Tanks FRS #3 Outfall Channel, also called the Jackrabbit Trail Channel, was based on future conditions, and therefore is compared against this project's Future with CIP model. Land use differences exist between the current design model for the Jackrabbit Trail channel and this model in the W21, W21A, W28 and W28A subbasins. The main difference is the assumption of the amount of development immediately adjacent to the White Tanks #3 Outfall channel (see discussion above in Section 3.5.2.3).

Additionally, the design of the channel in the future will accommodate a certain amount of flow to be released from the FRS through a gated outfall. The modeling results shown in this project have the gates closed, and therefore do not show the contribution of flow from the outfall. This is per direction from the FCDMC, as the gates will not likely be opened to release flow into the channel until after a peak event has passed. The future design of the channel should consider potential outflow from the FRS during non-peak conditions.

5.1.16 White Tanks FRS #4 Flood Retarding Structure

Flows into the White Tanks FRS #4 are slightly lower than the previous ADMPU models. Unlike FRS #3, the FRS #4 watershed has been developed, mainly the Verrado Master Plan Community that added retention in the lower portion of the watershed. The watershed that drains into FRS #4 contained previous retention from the proving ground that pre-dated the master plan community. Therefore, unlike FRS #3, RTIMP changes did not result in significant differences at the structure in this watershed. The main explanation for decrease in flows and volumes appears to be due to the NOAA Atlas 14 precipitation.

5.1.17 White Tanks FRS #4 Outlet Channel

The White Tanks #4 Outlet Channel is a recommended element of the Buckeye ADMP study. It will take outflows from White Tanks #4 FRS into the Buckeye area via new channels and basins roughly following the UPRR alignment between Southern and Broadway Roads.

Due to the timing of this study and the Buckeye ADMP study, only conceptual information was available for the system. Therefore, the routing information and potential basins associated with this project were not modeled in detail and require further refinement in the future.

5.2 Floodplain Recommendations

In areas where the flows have changed significantly, it may be prudent to examine effective floodplains for re-study. **Table 5.2.1,** below, contains a summary of the effective FEMA FIS flows (04013CV001A, Revised September 30, 2005) compared to the results of this study, and **Figure 11** contains a graphical representation of the recommendations for potential re-study. However, please be aware that the models associated with the project were not developed for flood insurance purposes, and may not be valid for that purpose. Close examination into the assumptions associated with these models as compared to flood insurance regulations are necessary. Caution is advised in straight comparisons between the FIS flows and the flows developed in this project. The table below was created strictly for use by the FCDMC to aid them into determining locations for potential restudy.

In the mountains areas, there are floodplains that exist where a direct comparison was not available due to model structure limitations. These washes are: Cholla Wash, Waterfall Wash, Bedrock Wash, Bulldozer Wash, Osborn Road Wash, Tractor Wash, and Diversion Dike Wash. Additional concentration points would be necessary in the ADMPU AHA model to properly compare the flows with the effective FIS flows.

Table 5.2.1 – FIS Flow Comparisons

Floodplain	Location	2005 Effective FIS Flows (100 year, cfs)	L303/WT ADMPU AHA Flows (Existing Conditions, August 2009, cfs)	% Change	L303/WT ADMPU AHA Identifier
191st Avenue Wash	200' N of I-10	617	626	1%	CPW32
	at Indian School Road	147	578	293%	CPW29
	at Camelback Road	564	870	54%	DW28RE
Perryville Road Wash	at Camelback Road	470	562	20%	CPL50
	at intersection of Camelback Road and Perryville Road	1190	n/a	n/a	n/a
	At Glendale Avenue	1450	541	-63%	L40
Bullard Wash	at Lower Buckeye Road	4906	2141	-56%	CPB69
	At Yuma Road	4438	2101	-53%	CPB68
	Downstream of I-10	4446	1885	-58%	CPB65B
	Upstream of I-10	5319	2883	-46%	CPB65A
	at Indian School Road	2630	2671	2%	CPB57

Table 5.2.1 – FIS Flow Comparisons (con't)

Floodplain	Location	2005 Effective FIS Flows (100 year, cfs)	L303/WT ADMPU AHA Flows (Existing Conditions, August 2009, cfs)	% Change	L303/WT ADMPU AHA Identifier
Bullard Wash (con't)	at Bethany Home Road	1856	2867	54%	CPB54
	Just downstream of Litchfield Road	450	839	86%	CPB02
Camelback Wash	at Reems Road	206	1234	499%	CPB48
	at Sarival Road	1086	464	-57%	CPB46
	at Cotton Lane	518	1474	185%	CPL53
	Just downstream of Perryville Road	883	562	-36%	CPL50
Lower El Mirage Wash	At confluence with Agua Fria River	1753	297	-83%	CPD54
	At confluence with Lower El Mirage Wash Tributary	1771	402	-77%	CPD42
	At Dysart Road	845	132	-84%	CPD39
Lower El Mirage Wash Tributary	Upstream of confluence with Lower El Mirage Wash	1170	370	-68%	D27D42
	At the intersection of Greenway Road and Dysart Road	856	980	14%	CPD14
	At the intersection of Greenway Road and Litchfield Road	545	1138	109%	CPD13
Interstate 10 - Jackrabbit Trail West of Tuthill Road	0.50 miles upstream of the confluence with Jackrabbit Trail Wash	1030	527	-49%	W38W37
Dale Creek Wash	At Litchfield Park Detention Facility (Dreaming Summit)	520	936	80%	CPB09
Beardsley Canal Wash	Downstream of Northern Avenue	3655	6091	67%	CPW13
	Upstream of Northern Avenue	5141	5627	9%	CPW12
	At confluence with Cholla Wash	3816	n/a	n/a	n/a
	Downstream of Olive Avenue	1755	n/a	n/a	n/a
	Upstream of Olive Avenue	2245	2514	12%	CPW05
	At Peoria Avenue	296	250	-16%	CPW01
Jackrabbit Trail Wash	At Thomas Road	1105	1050	-5%	CPW36
	at Indian School Road	726	985	36%	CPW35
	at Camelback Road	221	n/a	n/a	n/a
	At Medlock Drive	187	n/a	n/a	n/a
Tuthill Dike Wash	Downstream of I-10	4061	4776	18%	W58S60

Table 5.2.1 – FIS Flow Comparisons (con't)

Floodplain	Location	2005 Effective FIS Flows (100 year, cfs)	L303/WT ADMPU AHA Flows (Existing Conditions, August 2009, cfs)	% Change	L303/WT ADMPU AHA Identifier
Tuthill Dike Wash (con't)	Upstream of I-10	5503	7290	32%	CPW58
	At McDowell Road and the confluence with Bulldozer Wash	6601	7483	13%	CPW57
	At Thomas Road and the confluence with Caterpillar Wash	6110	6695	10%	CPW54
	At Indian School Road and the confluence with Tractor Wash	3011	3823	27%	CPW46B
	Downstream of Camelback Road	1261	n/a	n/a	n/a
	At the confluence with Caterpillar Dike Wash	1108	2983	169%	CPW27

* This project not developed for flood insurance purposes. Caution is advised in straight comparisons between the FIS flows and the ADMPU AHA flows

5.3 Locations for further study

The results Loop 303/White Tanks ADMPU AHA project indicate certain areas of the watershed may benefit from further study. These locations were discussed in detail above. A summary of the recommendations include:

- Investigate the effects of the new increased flow estimates in Bullard Wash between Luke AFB and I-10, and the decreased flow estimates between I-10 and the Gila River.
- Examine Colter Channel for design capacity and flooding impacts based on the increased flow estimates. A potential solution may involve maximizing storage in the Dreaming Summit detention basin (Old Murphy Dam site).
- Modify the conceptual design of the Loop 303 drainage system based on the new estimates developed with this project.
- Investigate the areas of Bell Road near Reems Road and the area of Sun City West near RH Johnson Boulevard and Camino Del Sol for potential flooding.
- Tuthill Dike Wash near Interstate 10 has areas of potential split flows. These areas may benefit from additional detailed study.
- Several floodplains in the area may benefit from restudy. These areas are summarized in **Figure 11**.
- The new estimates of flows and volumes arriving to White Tanks #3 FRS are increased over the previous estimates. Although they appear to be within the capacity of the structure, further study may be warranted to ensure optimum operation of the structure.

6.0 REFERENCES

An additional list of references is contained in the *Data Collection Memo*, Loop 303/White Tanks ADMPU Area Hydrologic Analysis in Maricopa County, Arizona, by HDR for the Flood Control District of Maricopa County, October 2008.

Flood Control District of Maricopa County, *Drainage Design Manual for Maricopa County, Arizona*, November 2003 (Draft).

Flood Control District of Maricopa County, Drainage Design Management System, Version 4.1.9.

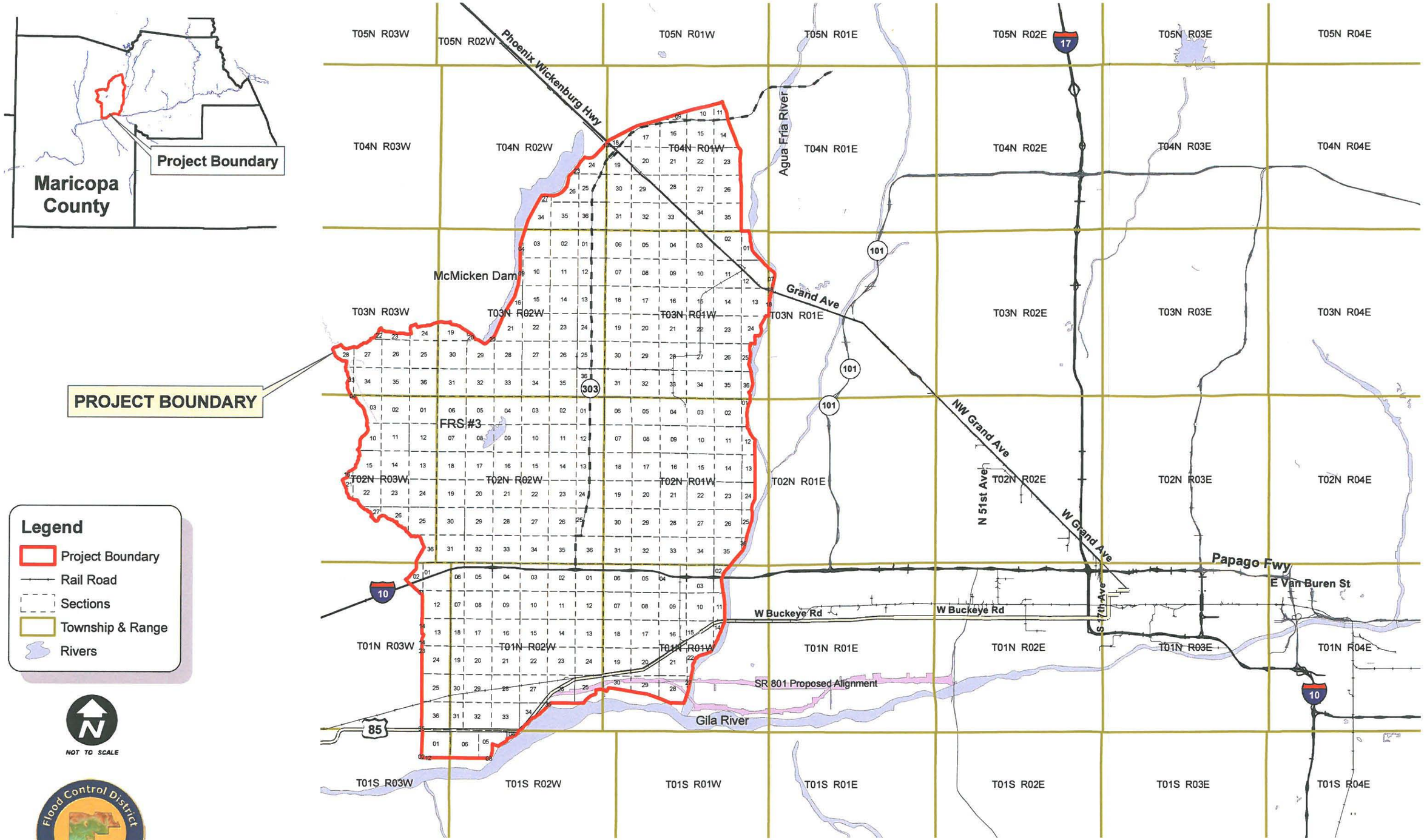
Federal Emergency Management Agency, *Flood Insurance Study Maricopa County, Arizona and Incorporated Areas*, Flood Insurance Study Number 04013CV001A, Revised September 30, 2005.

U.S. Army Corps of Engineers, *HEC-1 Flood Hydrograph Package User's Manual*, September 1990.

7.0 LIMITATIONS

The analyses presented in this report were prepared for the purpose of identifying flood hazards associated with the 100-year return period. Peak flow rates are based on conditions described in this report and application of Maricopa County minimum standards. Topographic mapping was prepared at a two foot contour interval in 1990, and occasional spot topographic mapping prepared from 2008 aerial photography and reflect existing conditions at the time of the flights. The results of these analyses could be subject to change as a result of changes in watershed condition, impacts of upstream or downstream projects on flow dynamics or peak flows, or changes in the floodplain as a result of erosion, deposition or modifications by others. Future studies that are based on superior technical methods, better scientific data or more accurate topographic mapping may result in changes to the estimates presented herein. Hydraulic analysis methods were prepared in accordance with the normal standard of care for drainage studies in Maricopa County for the preparing data for use in floodplain management.

Future users of the data contained herein should be cautioned that the data contained in this study may not be sufficient when more detailed site specific information is needed to support design of any features located in or near the floodplain areas shown and/or changes have occurred that modify flow conditions. In addition, areas shown in the floodplain are only those areas potentially subject to flooding from 100-year flows for the watercourses included in this study. Tributaries or adjoining watercourses will also have areas that are subject to flooding that are not included in this study and flooding outside of the areas shown will occur from events that exceed the 100-year peak flow estimates used in this study. Therefore, the results presented herein, should only be used for the express purpose for which they are intended.



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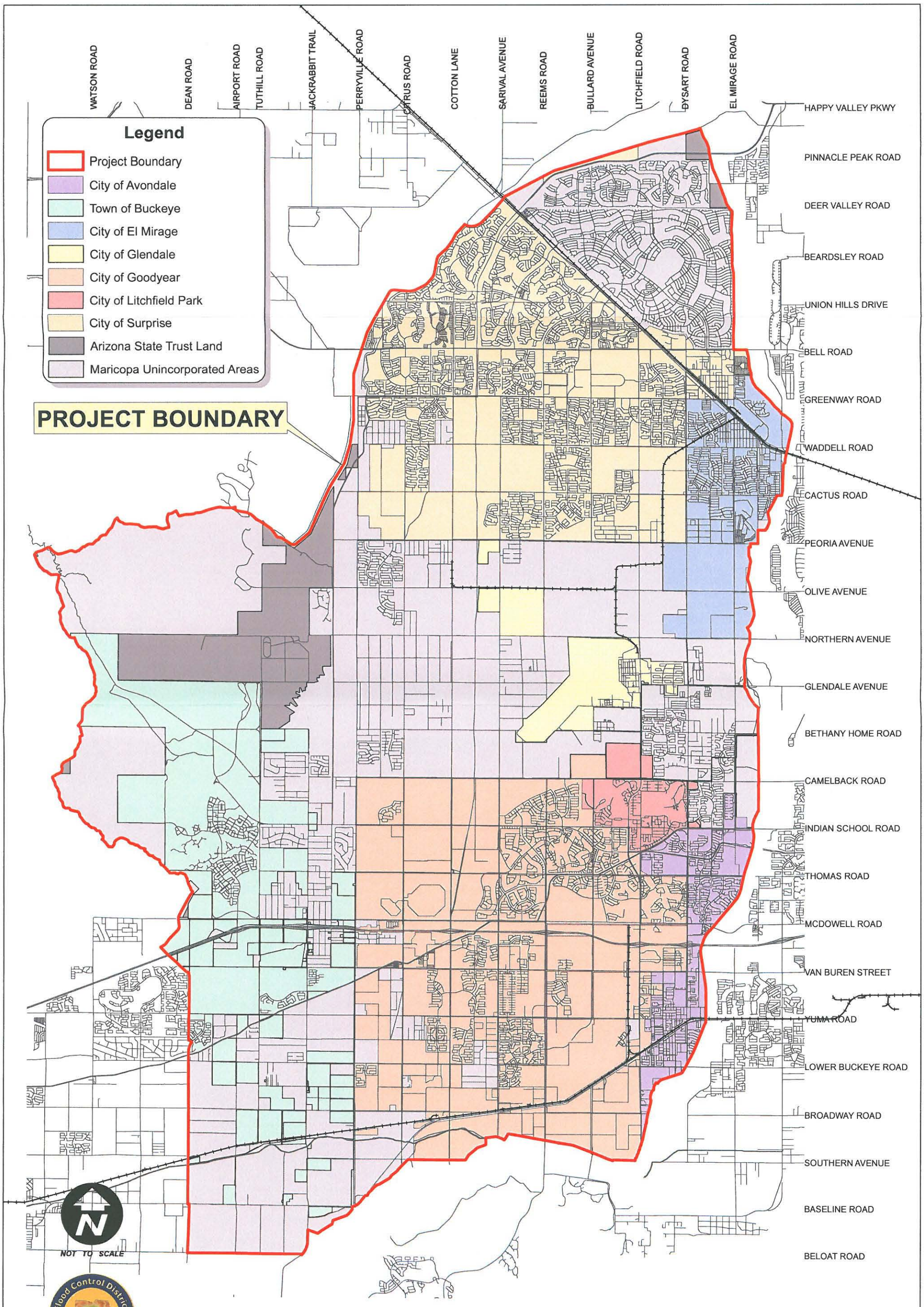
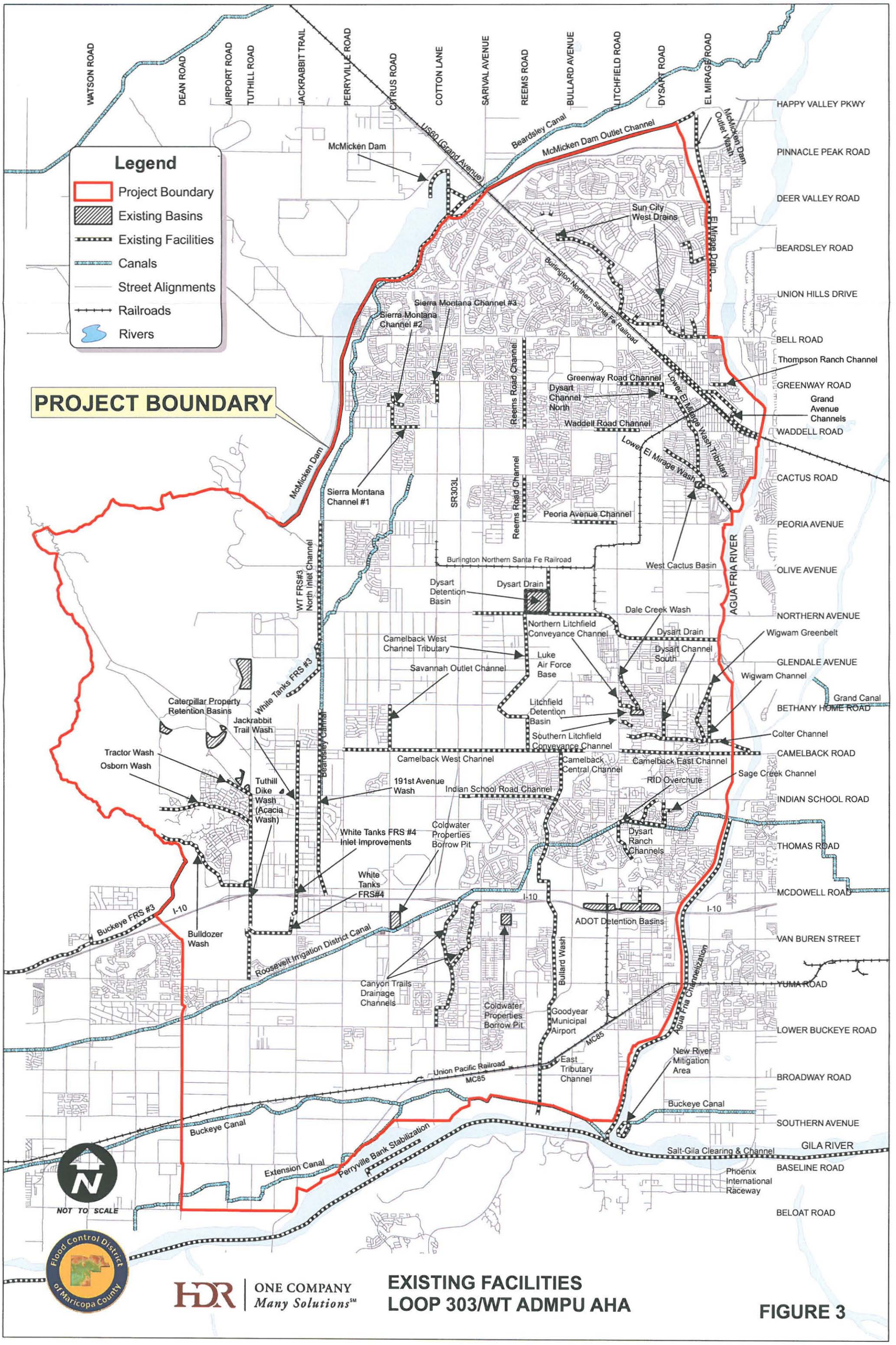
VICINITY MAP LOOP 303/WT ADMPU AHA

FIGURE 1



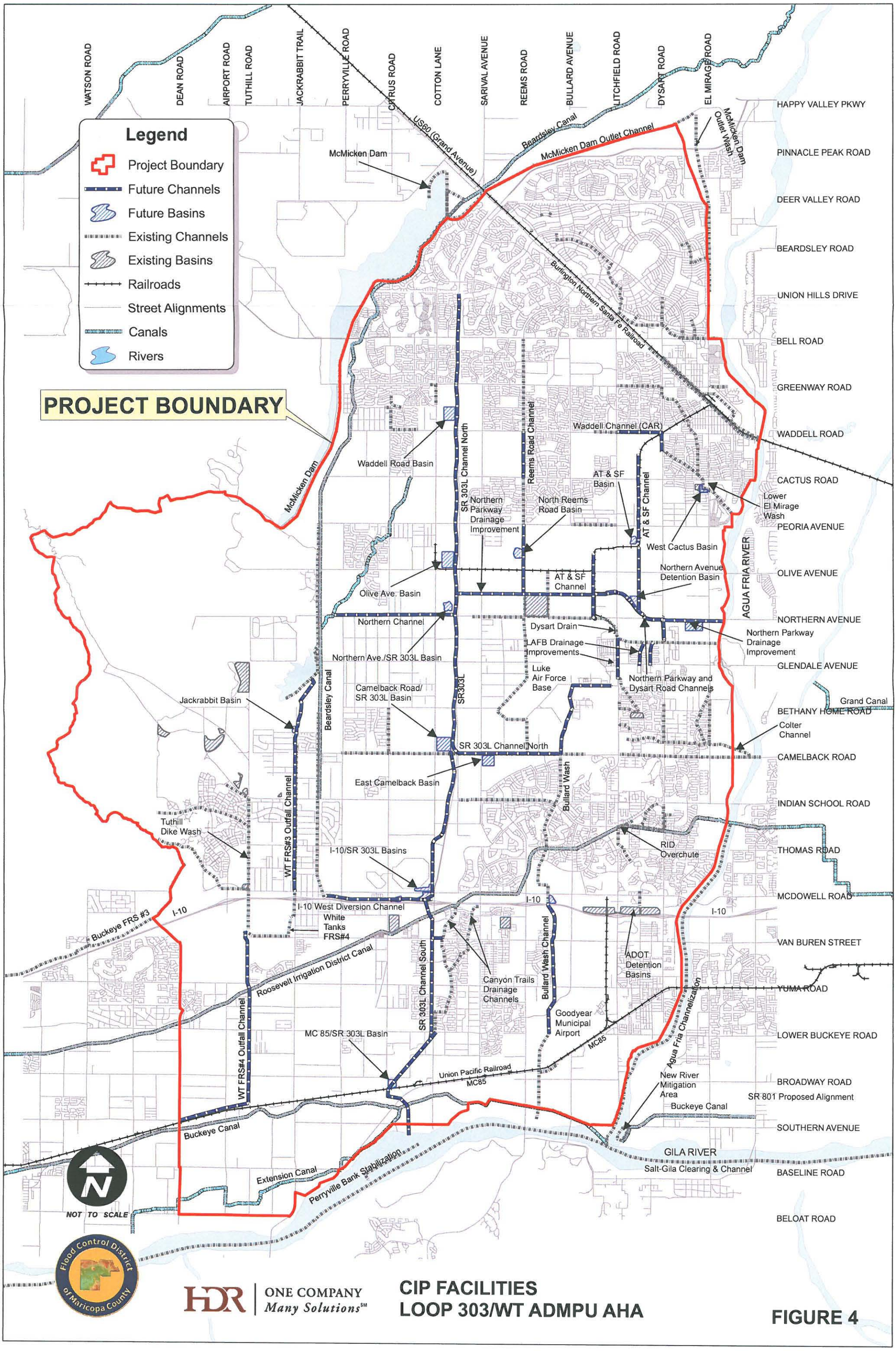
PUBLIC STAKEHOLDER BOUNDARIES
LOOP 303/WT ADMPU AHA

FIGURE 2



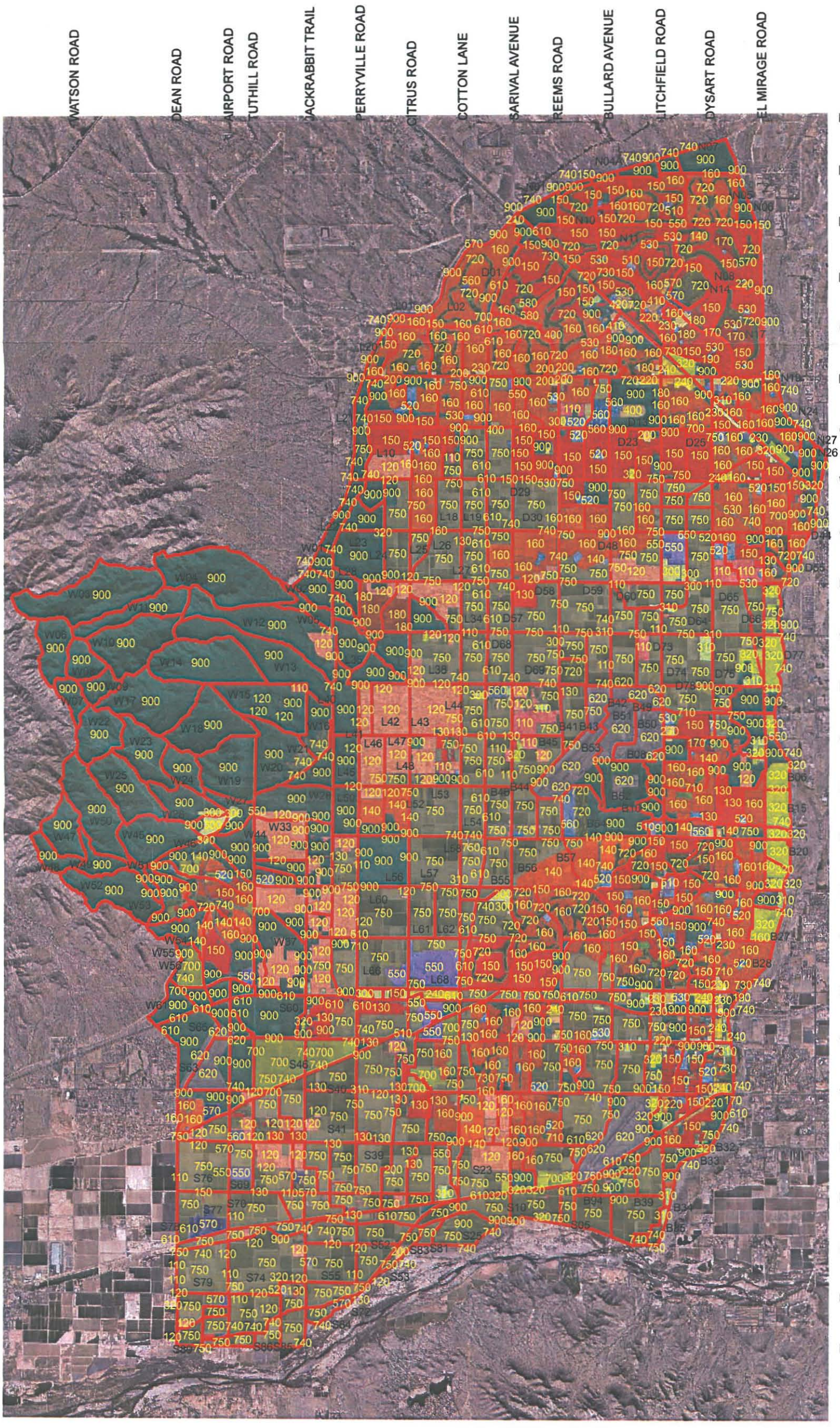
EXISTING FACILITIES
LOOP 303/WT ADMPU AHA

FIGURE 3



CIP FACILITIES
LOOP 303/WT ADMPU AHA

FIGURE 4



LOOP 303 / WT ADMPU AHA EXISTING LAND USE

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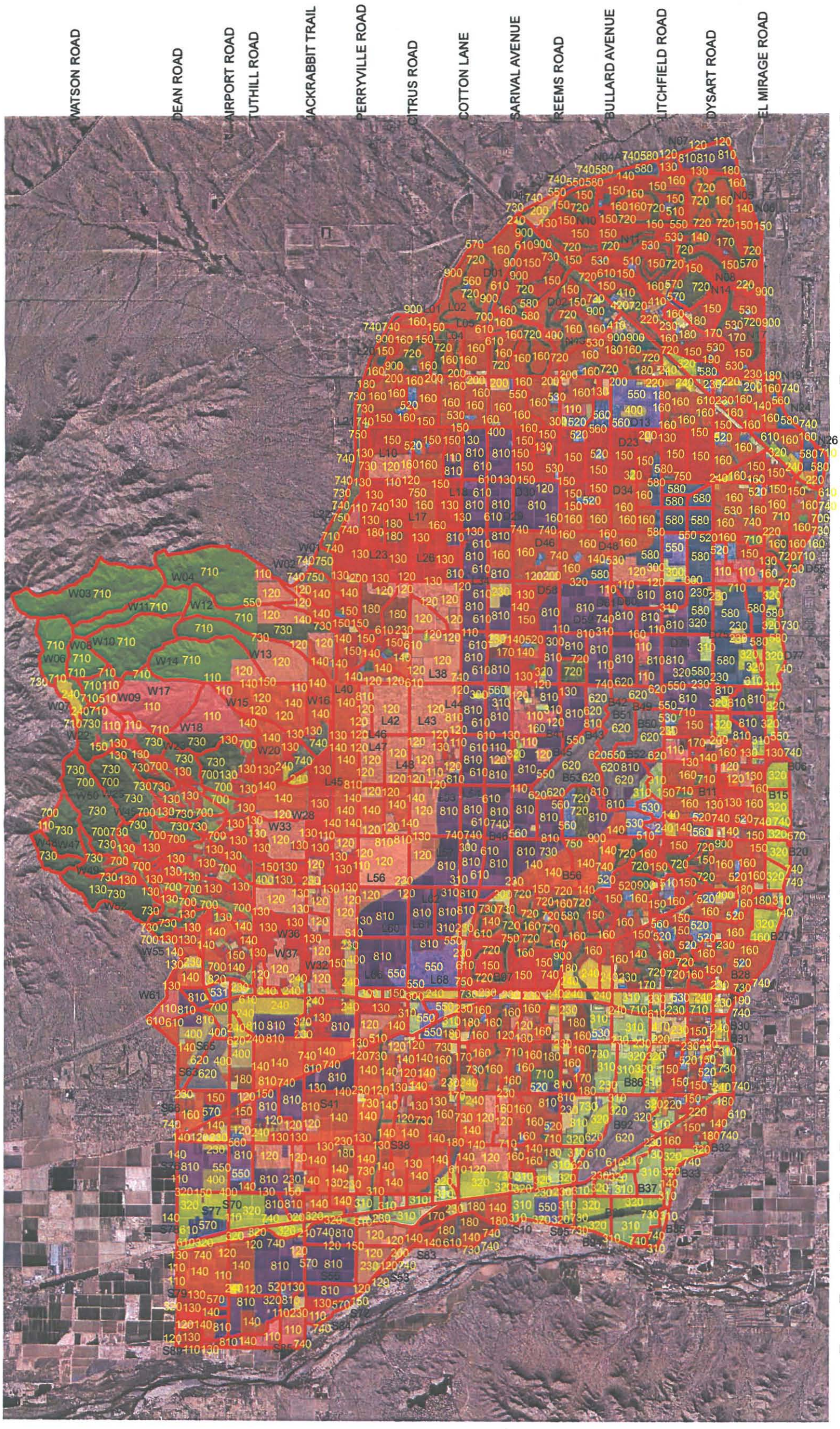
Figure 5



LOOP 303 / WT ADMPU AHA FUTURE LAND USE

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Figure 6

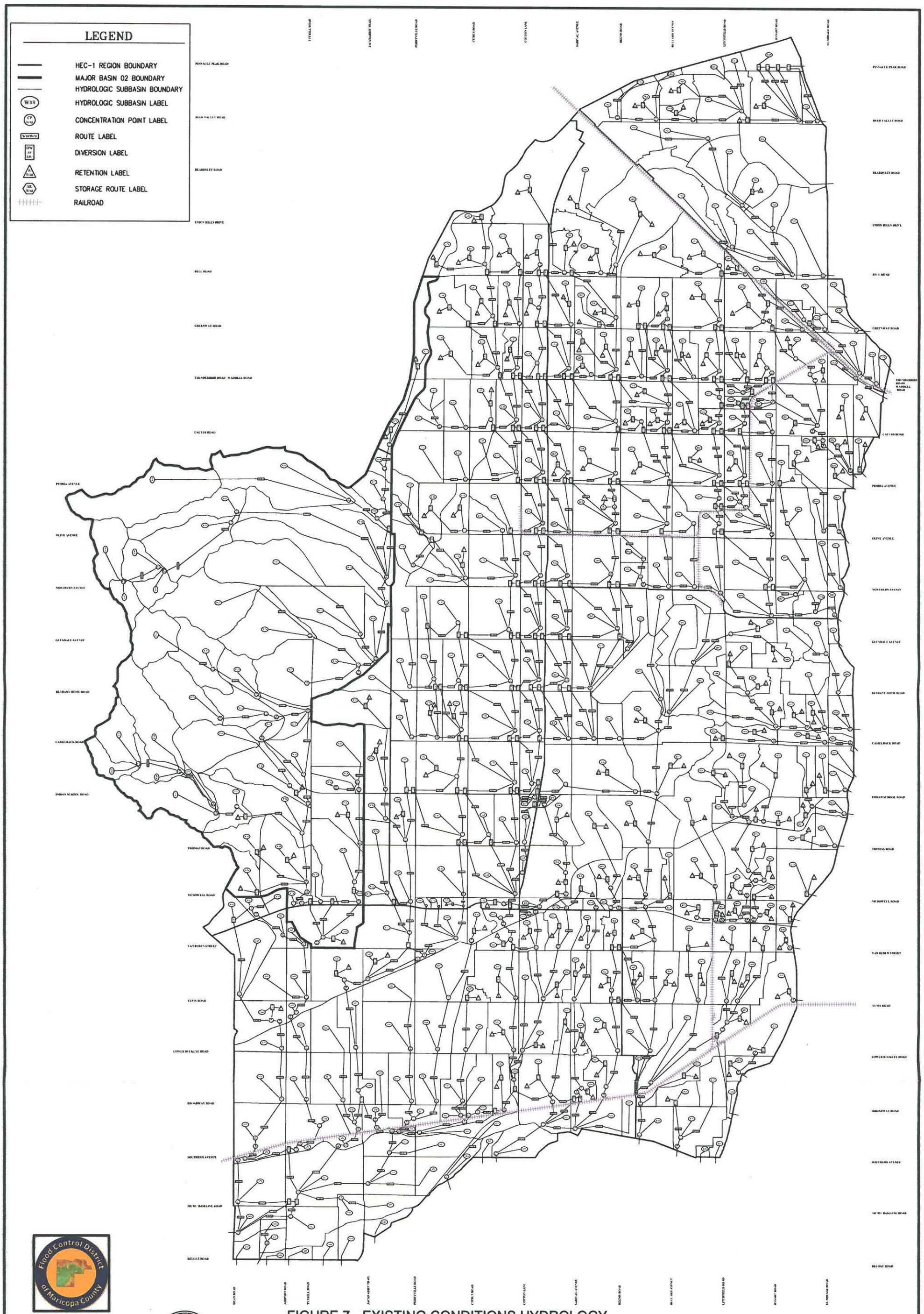
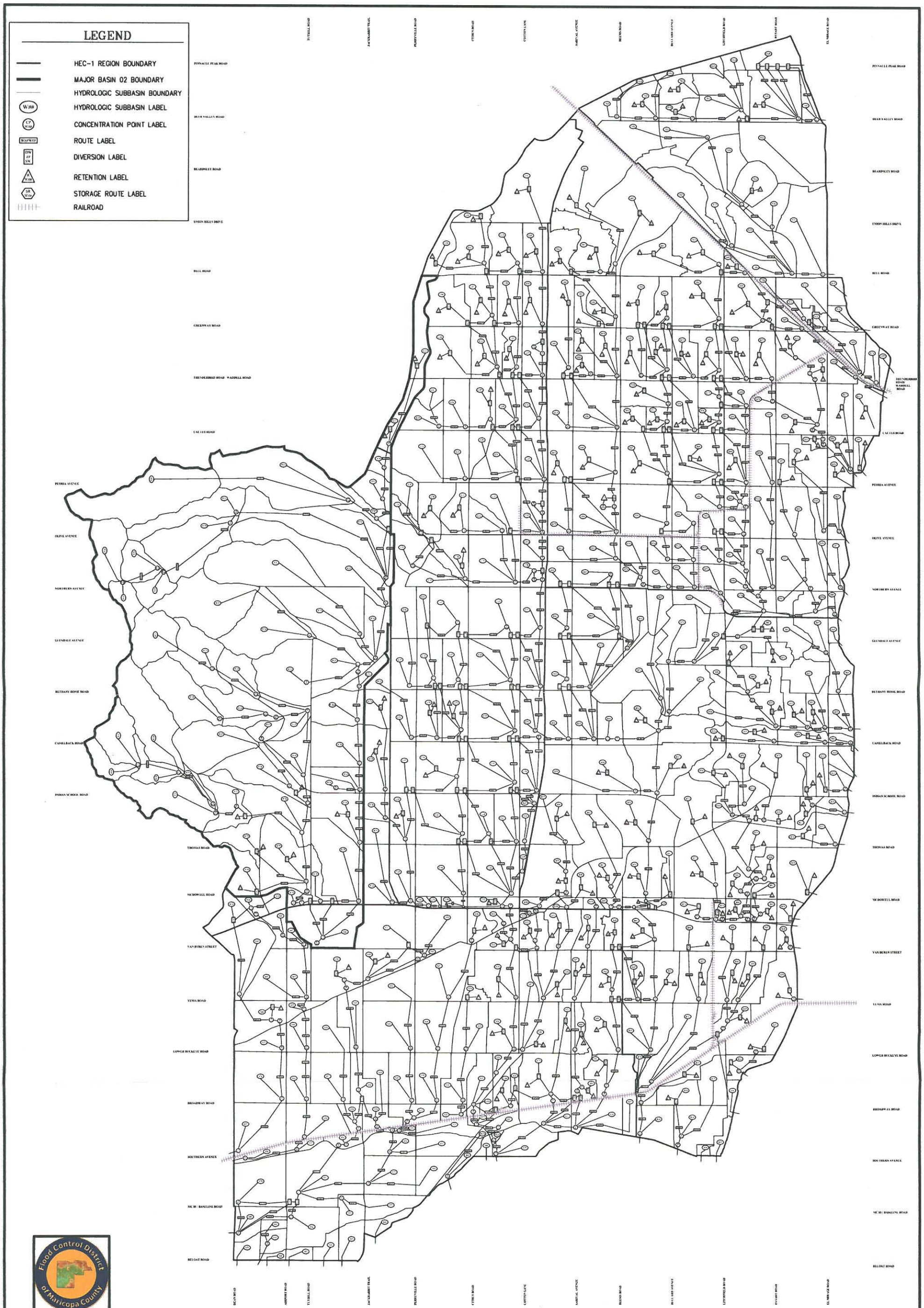


FIGURE 7 - EXISTING CONDITIONS HYDROLOGY HEC-1 SCHEMATIC

LOOP 303 WHITE TANKS AREA DRAINAGE
MASTER PLAN AREA UPDATE HYDROLOGIC ANALYSIS
CONTRACT NUMBER: FCD 2007C031
AUGUST, 2009



Flood Control District of Maricopa County

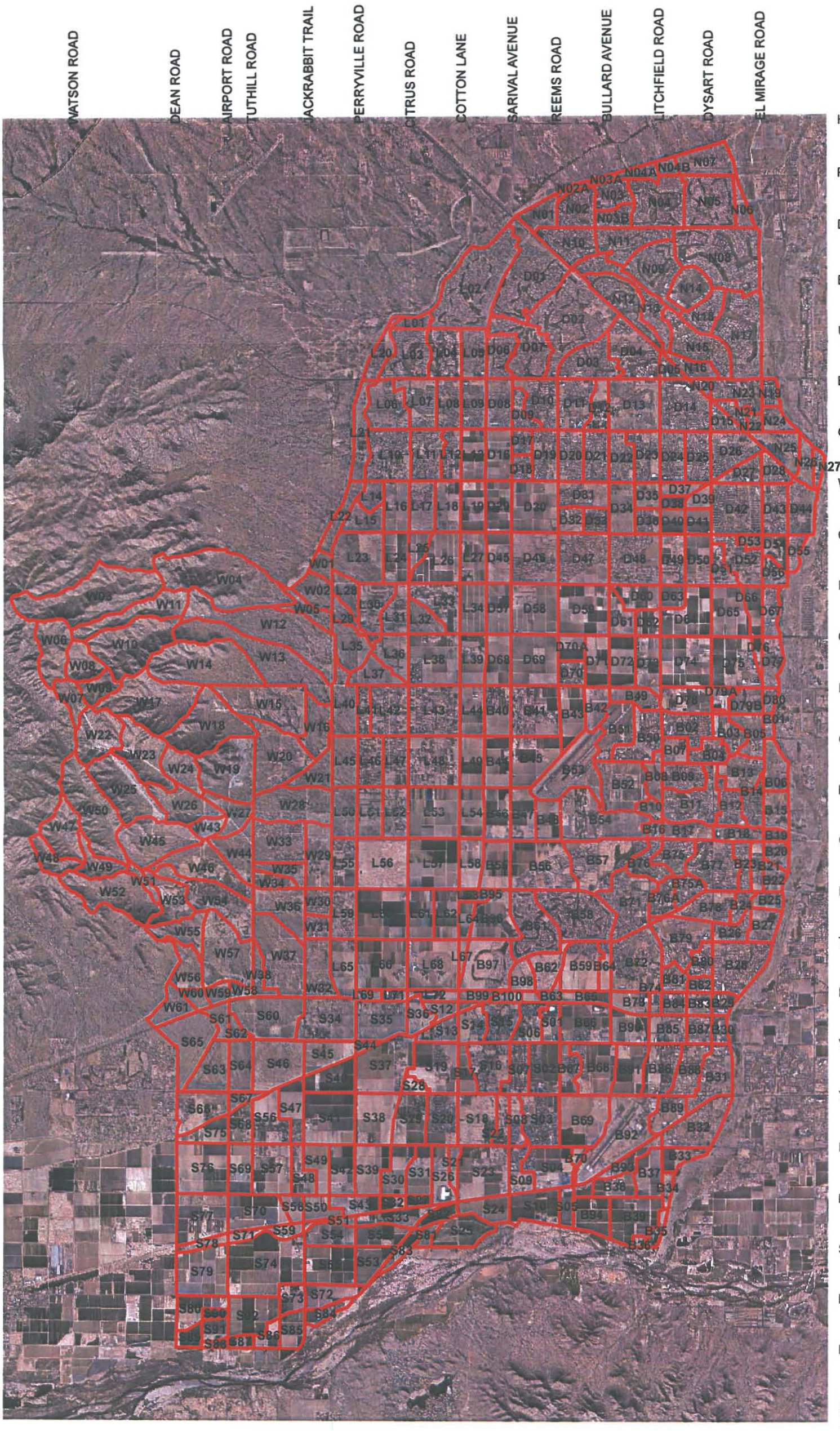
HDR
ONE COMPANY | Many Solutions™

Registered Professional Engineer (Civil)
CERTIFICATE NO. 35571
LINDA A. POTTER
Date Signed
ARIZONA, U.S.A.
EXPIRES 12-31-2009

FIGURE 8 - CAPTIAL IMPROVEMENT PROJECT CONDITIONS HYDROLOGY HEC-1 SCHEMATIC

LOOP 303 WHITE TANKS AREA DRAINAGE
MASTER PLAN AREA UPDATE HYDROLOGIC ANALYSIS
CONTRACT NUMBER: FCD 2007C031
AUGUST, 2009

4000' 0' 4000' 8000'
SCALE: 1"= 4000 FEET



LOOP 303 / WT ADMPU AHA
DRAINAGE BASINS EXISTING CONDITIONS

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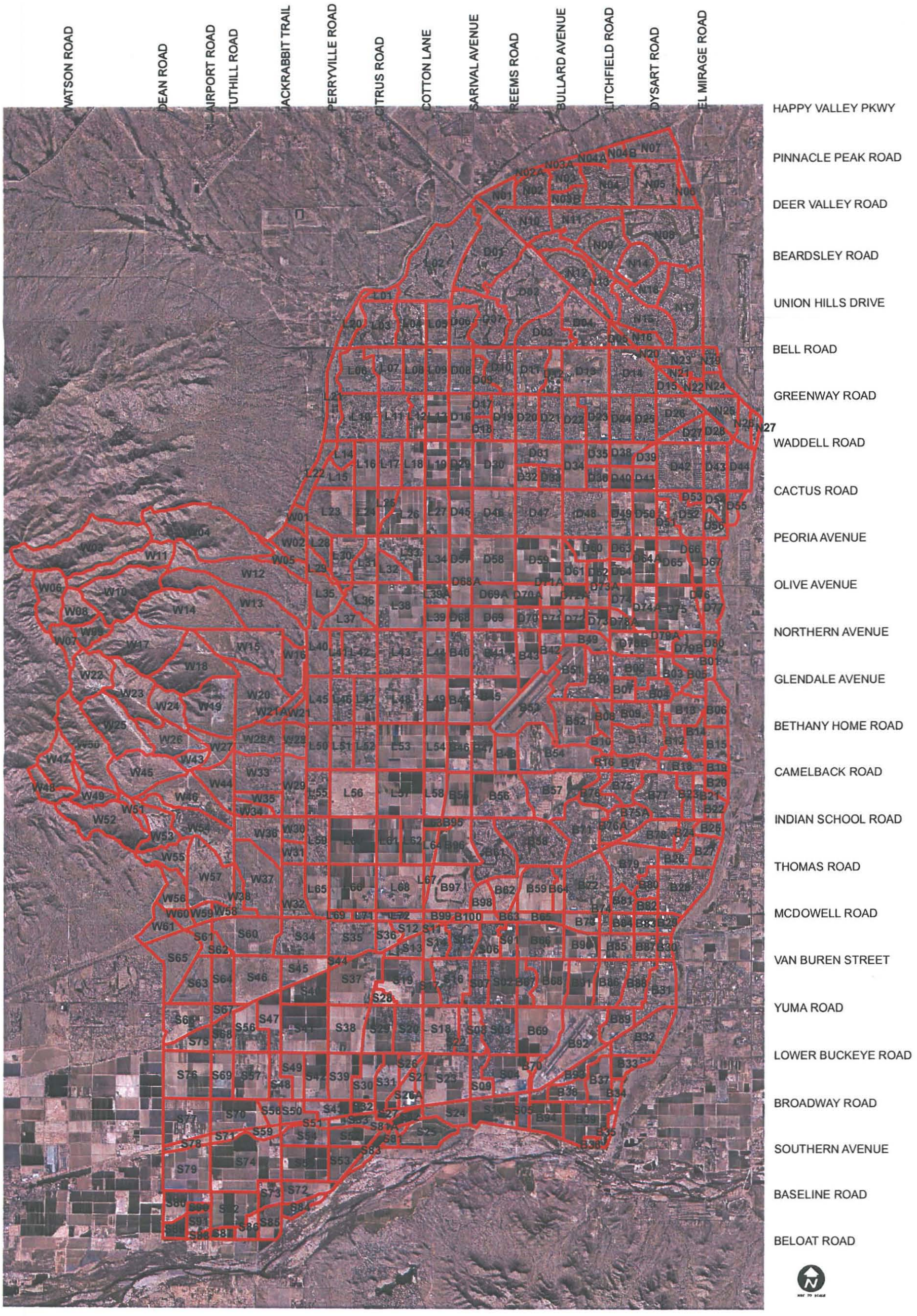
Figure 9



LOOP 303 / WT ADMPU AHA
DRAINAGE BASINS EXISTING CONDITIONS
WITH CAPITAL IMPROVEMENT PROJECTS

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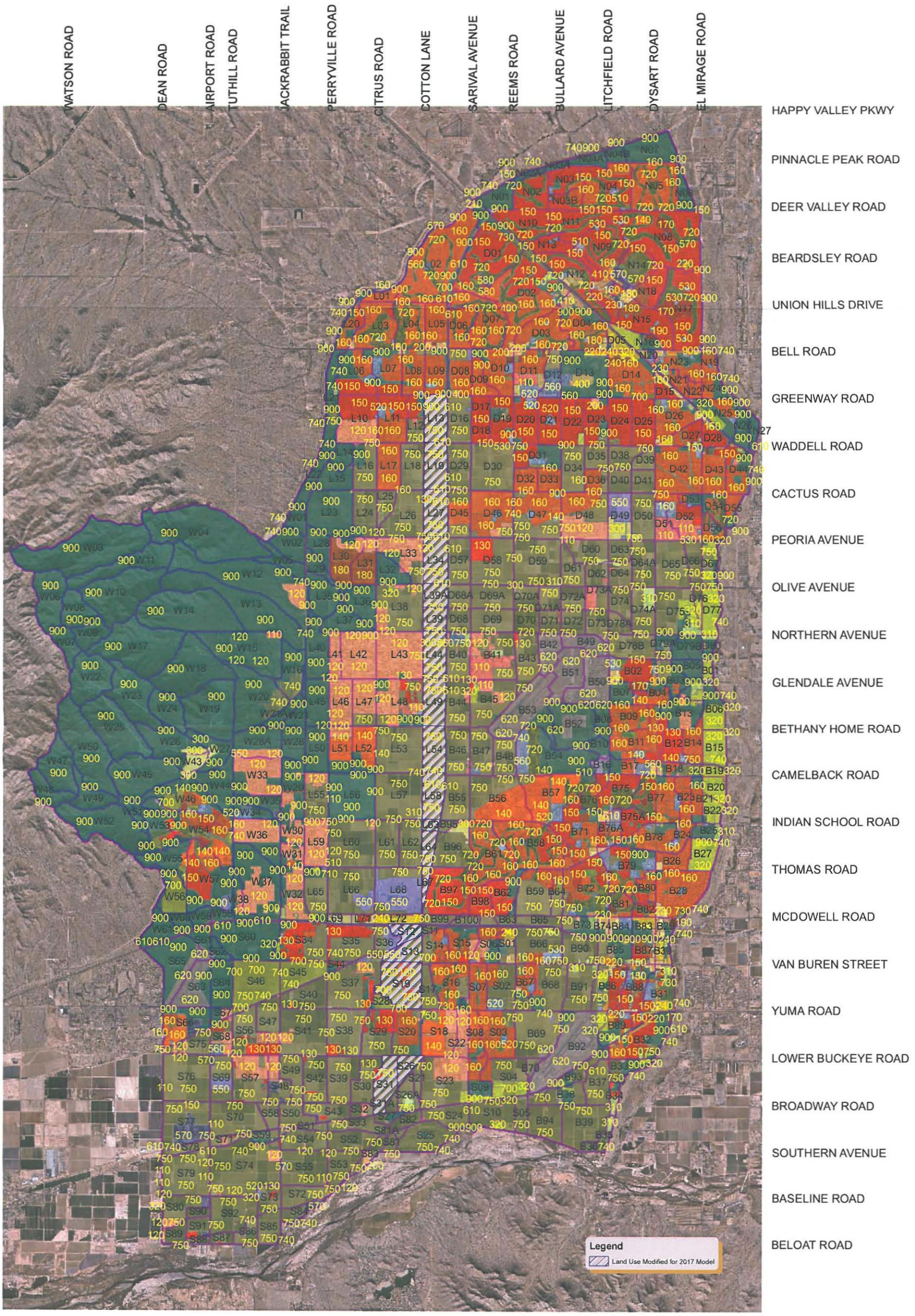
Figure 10

LOOP 303 / WT ADMPU AHA
FLOODPLAIN RECOMMENDATIONS

FIGURE 11



LOOP 303 / WT ADMPU AHA 2017 CONDITIONS LAND USE

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Figure 12

LOOP 303 WHITE TANKS
AREA DRAINAGE MASTER PLAN UPDATE
AREA HYDROLOGIC ANALYSIS
CONTRACT NUMBER: FCD 2007C031
EXISTING CONDITIONS HYDROLOGY
HEC-1 SCHEMATIC

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

AUTHORITY FOR STUDY

THE FLOOD CONTROL DISTRICT OF MARICOPA COUNTY (FCDMC) HAS CONTRACTED HDR TO PREPARE THIS STUDY UNDER THE CONTRACT NUMBER 2007C031. AND PROJECT CONTROL NUMBER 470.14.31.

PROJECT LOCATION

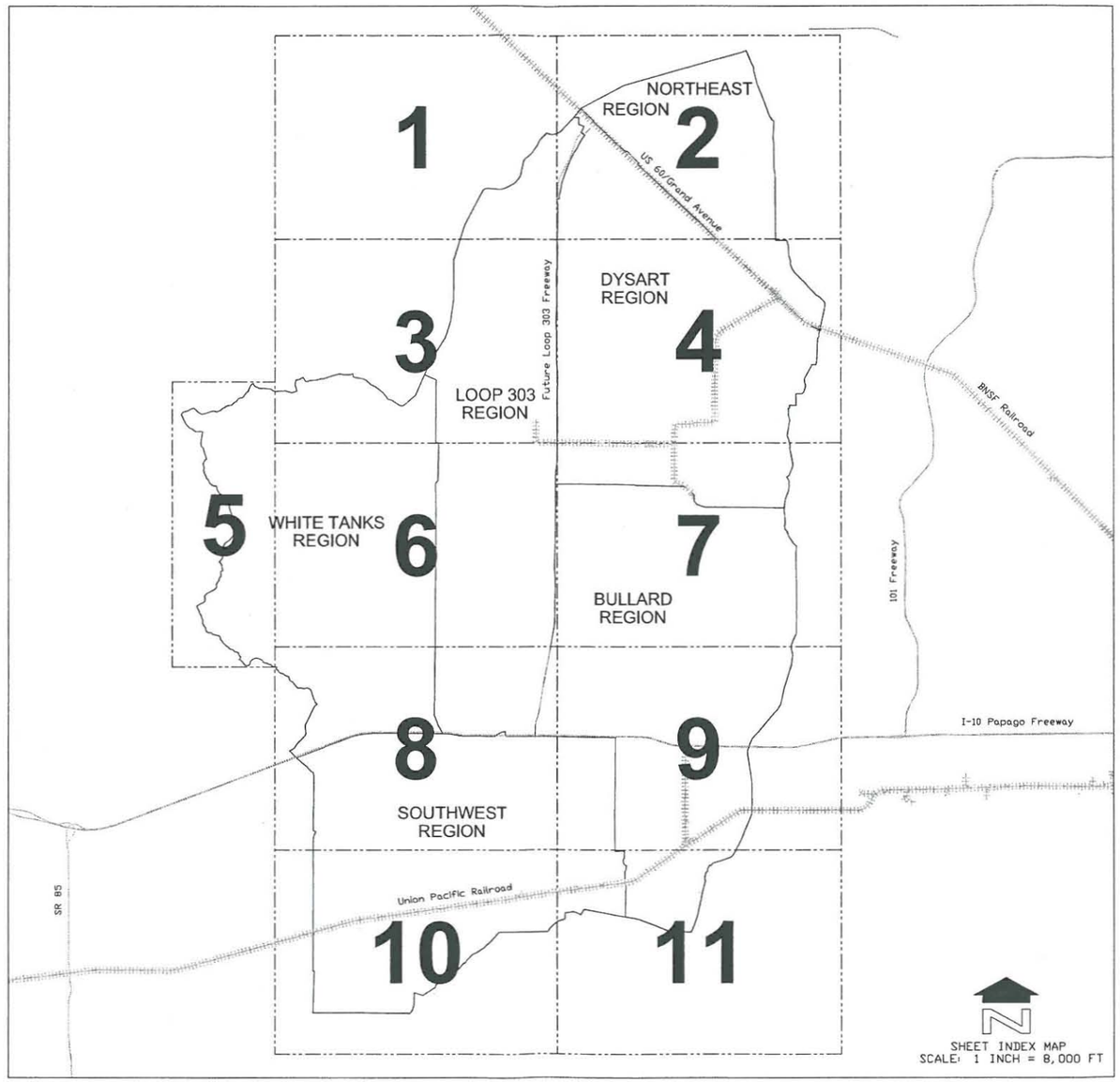
THE PROJECT SITE IS GENERALLY BOUNDED BY THE MOMICKEN DAM ON THE NORTH, AGUA FRIA RIVER ON THE EAST, THE GILA RIVER ON THE SOUTH AND THE WHITE TANK MOUNTAIN DIVIDE AND DEAN ROAD ON THE WEST. THE TOTAL ADMP AND WATERSHED AREA IS APPROXIMATELY 238 SQUARE MILES, WHICH INCLUDES UNINCORPORATED MARICOPA COUNTY AND PORTIONS OF AVONDALE, BUCKEYE, EL MIRAGE, GLENDALE, GOODYEAR, LITCHFIELD PARK, SURPRISE, AND LUKE AIR FORCE BASE.

SHEET INDEX

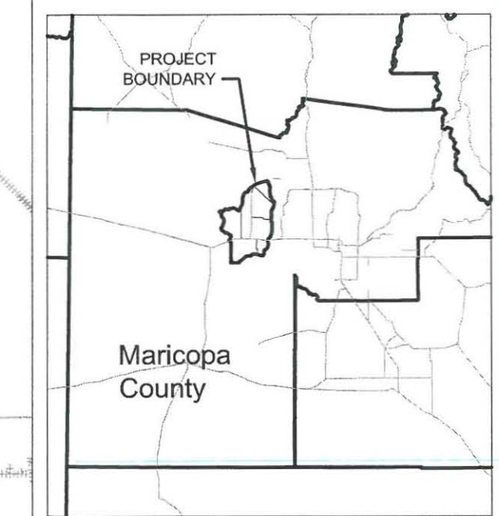
SHEET 01 – TUTHILL ROAD TO LOOP 303
PINNACLE PEAD ROAD TO BELL ROAD
SHEET 02 – LOOP 303 TO AGUA FRIA RIVER
HAPPY VALLEY PKWY TO BELL ROAD
SHEET 03 – DEAN ROAD ALIGNMENT TO LOOP 303
BELL ROAD TO OLIVE AVENUE
SHEET 04 – LOOP 303 TO AGUA FRIA RIVER
BELL ROAD TO OLIVE AVENUE
SHEET 05 – WHITE TANK MTN DIVIDE TO WATSON ROAD
PEORIA ROAD TO INDIAN SCHOOL ROAD
SHEET 06 – WATSON ROAD TO LOOP 303
OLIVE AVENUE TO INDIAN SCHOOL ROAD
SHEET 07 – LOOP 303 TO AGUA FRIA RIVER
OLIVE AVENUE TO INDIAN SCHOOL ROAD
SHEET 08 – DEAN ROAD TO LOOP 303
INDIAN SCHOOL ROAD TO LOWER BUCKEYE ROAD
SHEET 09 – LOOP 303 TO AGUA FRIA RIVER
INDIAN SCHOOL ROAD TO LOWER BUCKEYE ROAD
SHEET 10 – DEAN ROAD TO LOOP 303
LOWER BUCKEYE ROAD TO GILA RIVER
SHEET 11 – LOOP 303 TO AGUA FRIA RIVER
LOWER BUCKEYE ROAD TO GILA RIVER

ABBREVIATIONS

I – INTERSTATE
SR – STATE ROUTE



SHEET INDEX MAP
SCALE: 1 INCH = 8,000 FT



VICINITY MAP
SCALE: 1 INCH = 100,000 FT

JULY, 2009

HDR ENGINEERING, INC.
3200 East Camelback Road, Suite 350
PHOENIX, ARIZONA 85018-2311
(602) 522-7700

Existing Conditions

HEC-1 Concentration Point ID	100-yr, 24-hr Flow (cfs)	HEC-1 Concentration Point ID	100-yr, 24-hr Flow (cfs)	HEC-1 Concentration Point ID	100-yr, 24-hr Flow (cfs)	HEC-1 Concentration Point ID	100-yr, 24-hr Flow (cfs)	HEC-1 Concentration Point ID	100-yr, 24-hr Flow (cfs)
CP3227	623	CPB96	321	CPD70A	178	CPL71	314	CPS55	921
CPB02	839	CPB97	886	CPD71	632	CPL72	668	CPS57	399
CPB05	521	CPB99	481	CPD72	724	CPN01	479	CPS58	385
CPB06	796	CPD02	524	CPD73	961	CPN02	421	CPS59	367
CPB09	936	CPD04	1062	CPD74	563	CPN03B	482	CPS60	6461
CPB100	141	CPD05	337	CPD75	425	CPN04	1123	CPS61	365
CPB11	1191	CPD06	513	CPD77	629	CPN05	1084	CPS62	490
CPB12	1502	CPD07	425	CPD78	1385	CPN06	1016	CPS64	1398
CPB14	1936	CPD08	367	CPD79A	101	CPN09	1689	CPS65	773
CPB15	2450	CPD10	605	CPD79B	1709	CPN11	962	CPS66	567
CPB17	563	CPD12	272	CPD80	1708	CPN13	1531	CPS67	1114
CPB18	628	CPD13	1138	CPL03	60	CPN15	3749	CPS68	896
CPB19	561	CPD14	980	CPL04	17	CPN17	4912	CPS69	812
CPB22	389	CPD15	422	CPL05	386	CPN18	1797	CPS70	808
CPB24	439	CPD16	234	CPL07	50	CPN21	381	CPS71	734
CPB25	352	CPD18	25	CPL08	110	CPN22	311	CPS73	246
CPB27	533	CPD19	583	CPL09	10	CPN24	887	CPS74	1171
CPB33	241	CPD20	326	CPL11	440	CPN25	832	CPS75	286
CPB39	390	CPD21	306	CPL12	492	CPN26	932	CPS76	303
CPB40	781	CPD22	67	CPL13	443	CPRMS	470	CPS77	567
CPB41	537	CPD23	98	CPL15	554	CPS02	225	CPS78	563
CPB43	115	CPD24	291	CPL16	584	CPS03	68	CPS79	747
CPB44	582	CPD25	204	CPL17	559	CPS04	341	CPS80	1280
CPB45	947	CPD26	303	CPL18	618	CPS06	42	CPS83	84
CPB46	464	CPD27	491	CPL19	804	CPS07	33	CPS91	231
CPB47	1240	CPD28	714	CPL22	56	CPS08	29	CPS92	530
CPB48	1234	CPD29	199	CPL24	943	CPS09	84	CPW01	250
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CPB52	2082	CPD31	234	CPL27	1118	CPS11	493	CPW04	2357
CPB53	862	CPD32	13	CPL29	460	CPS12	414	CPW05	2514
CPB54	2253	CPD33	229	CPL31	114	CPS13	680	CPW07	1216
CPB55	908	CPD34	179	CPL32	378	CPS14	698	CPW08	1604
CPB56	872	CPD35	119	CPL34	876	CPS15	249	CPW09	2064
CPB57	2355	CPD36	553	CPL35	554	CPS16	633	CPW10	3121
CPB58	2352	CPD37	119	CPL36	460	CPS18	645	CPW11	3977
CPB59	2551	CPD38	122	CPL38	888	CPS19	205	CPW12	5627
CPB62	39	CPD39	132	CPL39	777	CPS20	299	CPW13	6091
CPB63	111	CPD40	136	CPL42	668	CPS21	828	CPW15	2177
CPB65	2636	CPD41	256	CPL43	1052	CPS23	380	CPW16	6977
CPB66	2650	CPD42	403	CPL44	985	CPS24	503	CPW18	1438
CPB67	241	CPD45	402	CPL45	781	CPS25	463	CPW20	8098
CPB68	2670	CPD46	624	CPL46	1172	CPS26	415	CPW23	2264
CPB69	2670	CPD47	96	CPL47	1444	CPS27	339	CPW24	2718
CPB70	2865	CPD48	176	CPL48	758	CPS29	303	CPW26	810
CPB72	1026	CPD49	724	CPL49	1106	CPS30	439	CPW27	2983
CPB74	1003	CPD50	348	CPL50	562	CPS32	623	CPW29	578
CPB75A	413	CPD53	240	CPL51	920	CPS33	201	CPW30	560
CPB76A	773	CPD54	297	CPL52	1226	CPS34	1557	CPW32	626
CPB78A	946	CPD57	696	CPL53	1474	CPS35	509	CPW35	985
CPB78B	1020	CPD58	1187	CPL54	1611	CPS37	472	CPW36	1050
CPB79	1031	CPD59	493	CPL56	394	CPS38	624	CPW37	1651

Future Conditions

HEC-1 Concentration Point ID	100-yr, 24-hr Flow (cfs)	HEC-1 Concentration Point ID	100-yr, 24-hr Flow (cfs)	HEC-1 Concentration Point ID	100-yr, 24-hr Flow (cfs)	HEC-1 Concentration Point ID	100-yr, 24-hr Flow (cfs)	HEC-1 Concentration Point ID	100-yr, 24-hr Flow (cfs)	HEC-1 Concentration Point ID	100-yr, 24-hr Flow (cfs)
CP3227	256	CPB95	291	CPD69	250	CPL66	479	CPS48	476	CPW51	2768
CPB02	692	CPB96	341	CPD70	286	CPL67	124	CPS50	398	CPW52	3956
CPB05	537	CPB97	885	CPD70A	231	CPL68	1079	CPS51	211	CPW53	3815
CPB06	620	CPB99	629	CPD71	281	CPL71	352	CPS54	196	CPW54	5874
CPB09	614	CPD02	535	CPD72	322	CPL72	1097	CPS55	204	CPW57	5875
CPB100	1028	CPD04	1062	CPD73	356	CPN01	156	CPS57	785	CPW58	5657
CPB11	1160	CPD05	337	CPD74	353	CPN02	72	CPS58	554	CPW60	77
CPB12	1382	CPD06	513	CPD75	198	CPN03B	449	CPS59	275		
CPB14	1348	CPD07	450	CPD77	665	CPN04	1067	CPS60	5052		
CPB15	1705	CPD08	283	CPD78	416	CPN05	1065	CPS61	447		
CPB17	552	CPD10	537	CPD79A	22	CPN06	981	CPS62	396		
CPB18	429	CPD12	258	CPD79B	531	CPN09	1689	CPS64	914		
CPB19	296	CPD13	220	CPD80	536	CPN11	962	CPS65	728		
CPB22	396	CPD14	188	CPL03	60	CPN13	1531	CPS66	270		
CPB24	414	CPD15	420	CPL04	17	CPN15	3744	CPS67	725		
CPB25	361	CPD16	263	CPL05	386	CPN17	4903	CPS68	496		
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CPB33	4	CPD19	521	CPL08	36	CPN21	366	CPS70	403		
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CPB40	757	CPD21	210	CPL11	439	CPN24	911	CPS73	366		
CPB41	1750	CPD22	28	CPL12	385	CPN25	911	CPS74	327		
CPB43	387	CPD23	24	CPL13	312	CPN26	862	CPS75	127		
CPB44	385	CPD24	42	CPL15	0	CPRMS	248	CPS76	223		
CPB45	760	CPD25	39	CPL16	0	CPS02	18	CPS77	851		
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CPB52	1640	CPD30	407	CPL24	0	CPS08	10	CPS91	328		
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CPB54	1859	CPD32	10	CPL27	433	CPS10	18	CPW01	150		
CPB55	273	CPD33	177	CPL29	12	CPS11	616	CPW02	454		
CPB56	248	CPD34	67	CPL31	57	CPS12	421	CPW04	3313		
CPB57	1732	CPD35	2	CPL32	54	CPS13	277	CPW05	3395		
CPB58	1652	CPD36	62	CPL34	622	CPS14	414	CPW07	1797		
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CPB65	1574	CPD40	1	CPL39	201	CPS19	17	CPW11	5672		
CPB66	1475	CPD41	8	CPL42	668	CPS20	12	CPW12	7608		
CPB67	19	CPD42	380	CPL43	1052	CPS21	311	CPW13	8200		
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CPB72	1146	CPD48	77	CPL47	1022	CPS26	142	CPW20	8751		
CPB74	980	CPD49	724	CPL48	1006	CPS27	114	CPW23	2738		
CPB75A	413	CPD50	264	CPL49	844	CPS29	411	CPW24	3131		
CPB76A	773	CPD53	170	CPL50	11	CPS30	241	CPW26	1084		
CPB78A	884	CPD54	285	CPL51	127	CPS32	210	CPW27	3128		
CPB78B	958	CPD57	470	CPL52	327	CPS33	92	CPW29	9		
CPB79	1122	CPD58	463	CPL53	623	CPS34	1235	CPW30	353		

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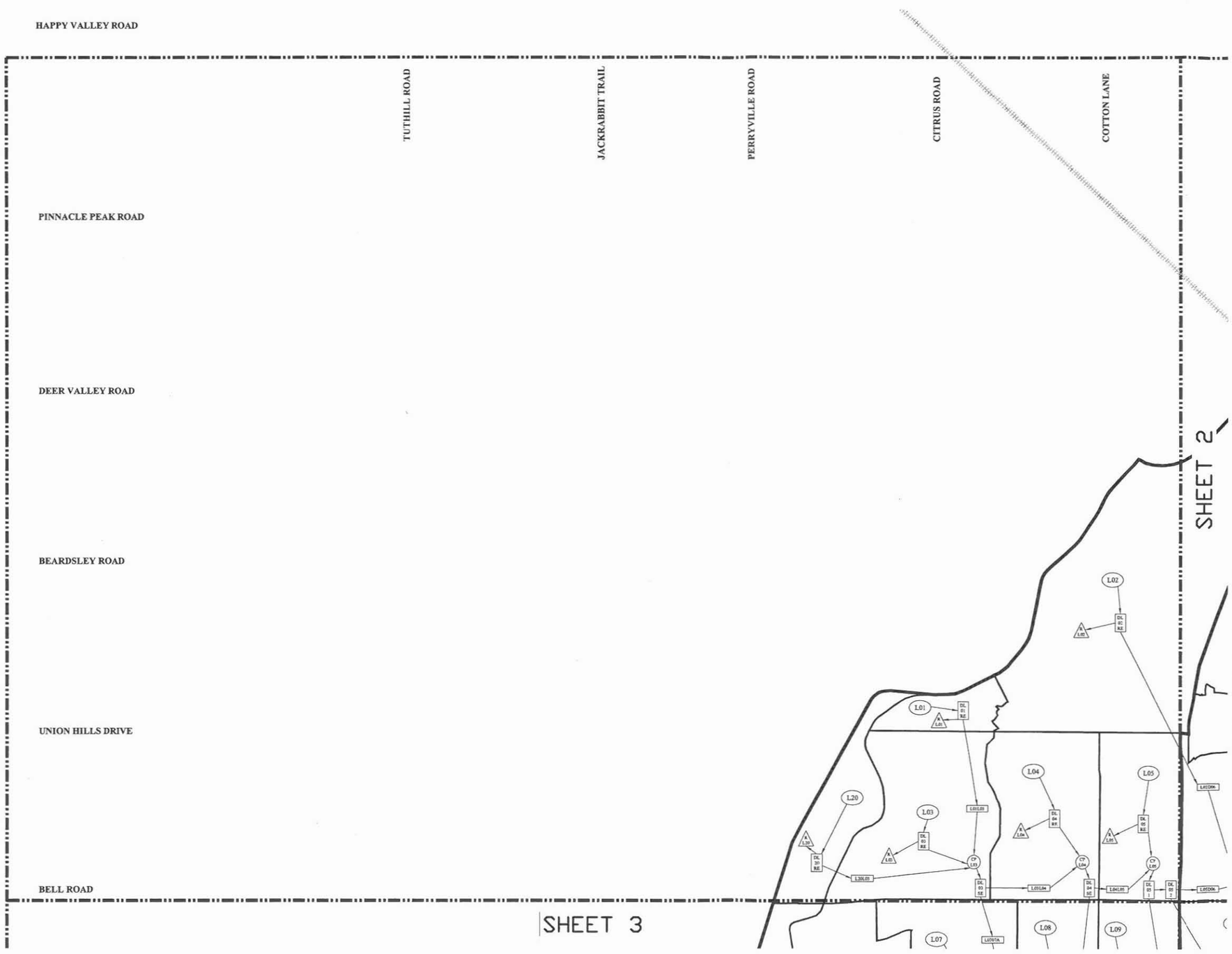
FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

LOOP 303 WHITE TANKS AREA DRAINAGE
MASTER PLAN AREA UPDATE HYDROLOGIC ANALYSIS
CONTRACT NUMBER: FCD 2007C031

EXISTING CONDITIONS HYDROLOGY
DRAFT HEC-1 SCHEMATIC

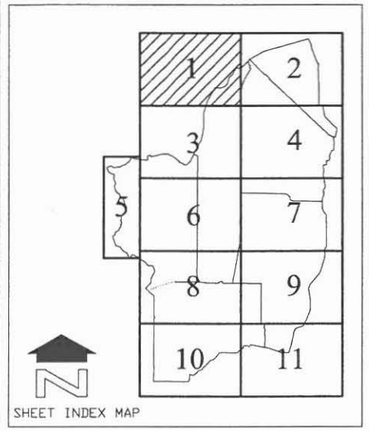
HDR ENGINEERING, INC.
3200 East Camelback Road, Suite 350
PHOENIX, ARIZONA 85018-2311
(602) 522-7700

	BY	DATE
DESIGN	LP	06/09/09
DESIGN CHK.	LP	06/09/09
PLANS	JM/JG	06/09/09
PLANS CHK.	LP	06/09/09



LEGEND

- HEC-1 REGION BOUNDARY
- HYDROLOGIC SUBBASIN BOUNDARY
- HYDROLOGIC SUBBASIN LABEL
- CONCENTRATION POINT LABEL
- ROUTE LABEL
- DIVERSION LABEL
- RETENTION LABEL
- STORAGE ROUTE LABEL
- MATCHLINE
- RAILROAD



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N

1500' 0' 1500' 3000'

SCALE: 1"= 1500 FEET

LEGEND

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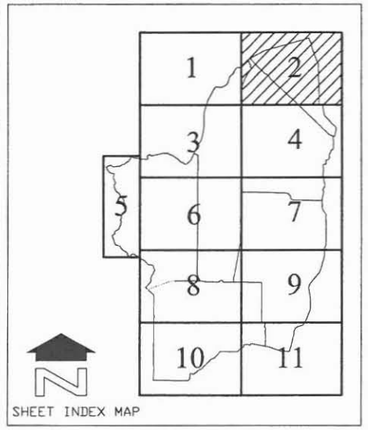
- W## — HYDROLOGIC SUBBASIN LABEL
- CP W## — CONCENTRATION POINT LABEL
- W or W## — ROUTE LABEL
- DIV W## S## — DIVERSION LABEL
- RA W## — RETENTION LABEL
- SR W## — STORAGE ROUTE LABEL
- MATCHLINE
- RAILROAD



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DRAFT_JM_090308

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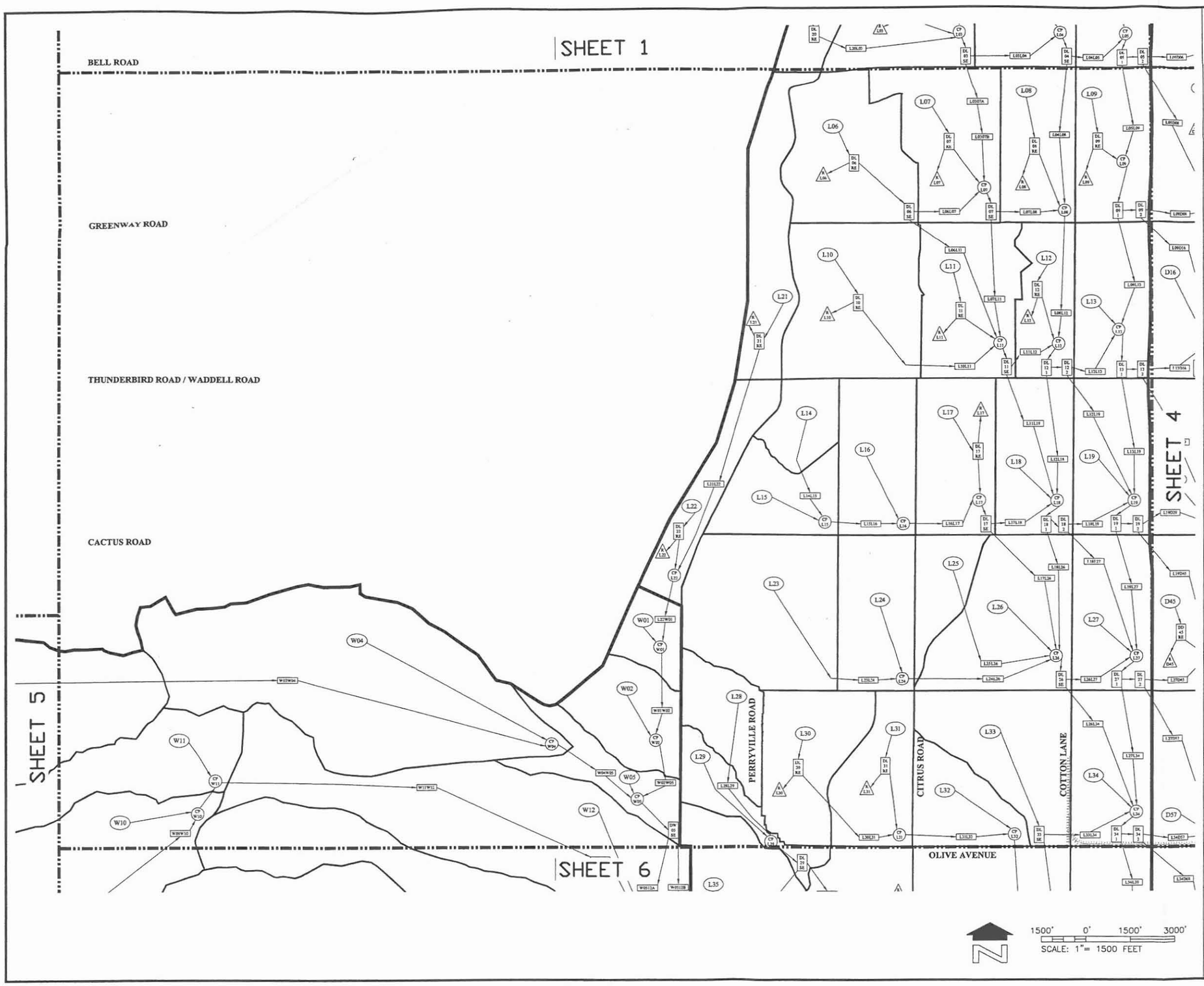
SCALE: 1"= 1500 FEET



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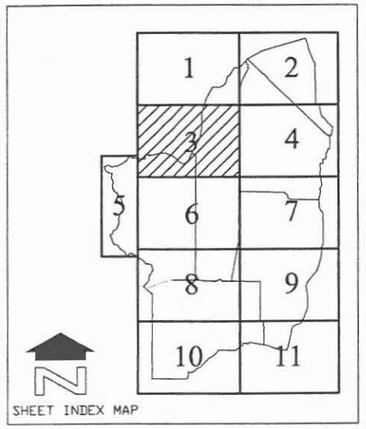

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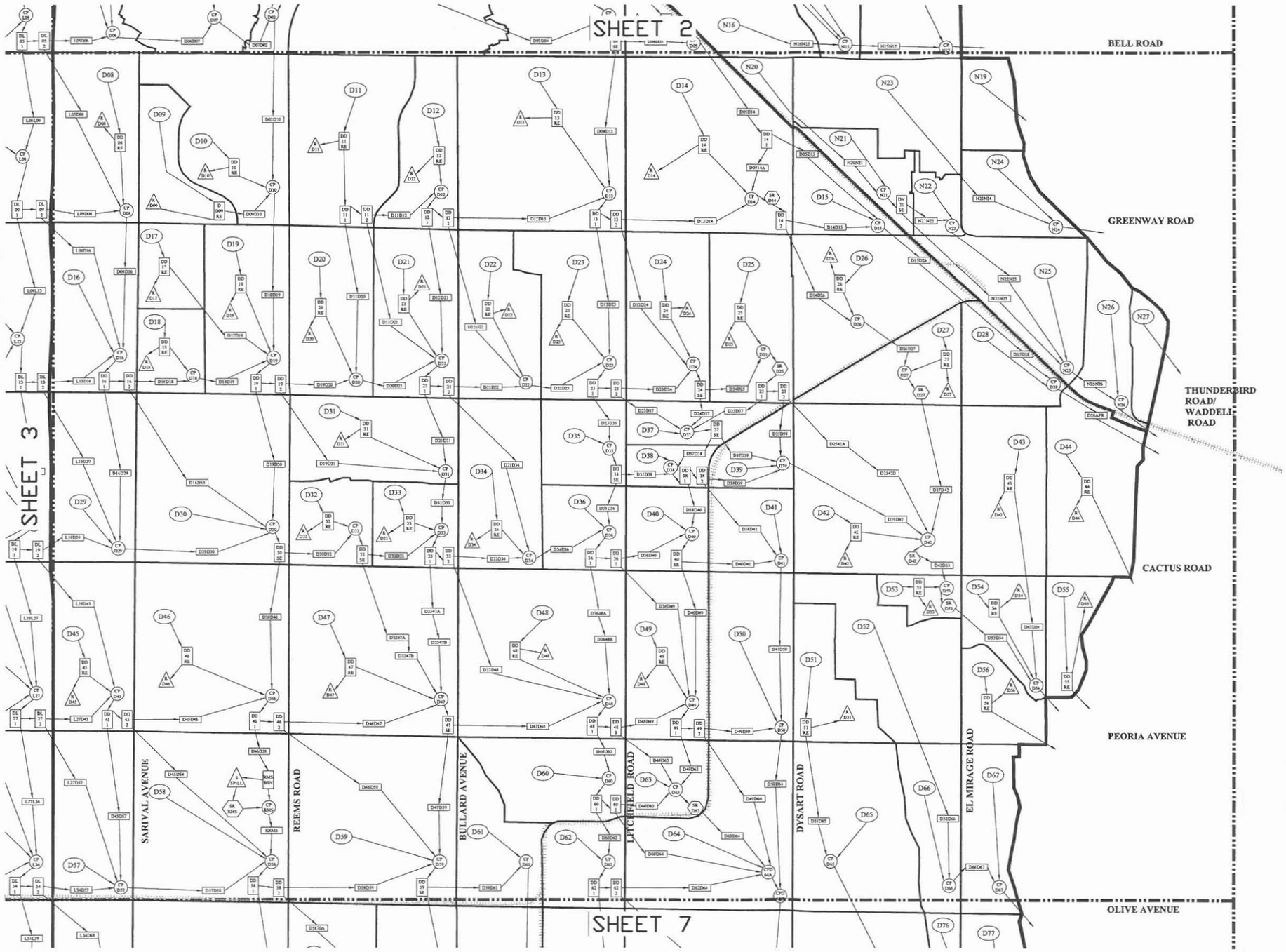

1500' 0' 1500' 3000'
SCALE: 1"= 1500 FEET

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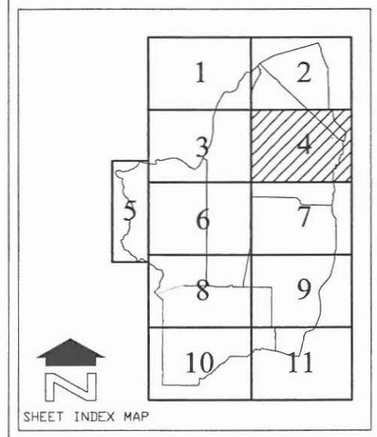

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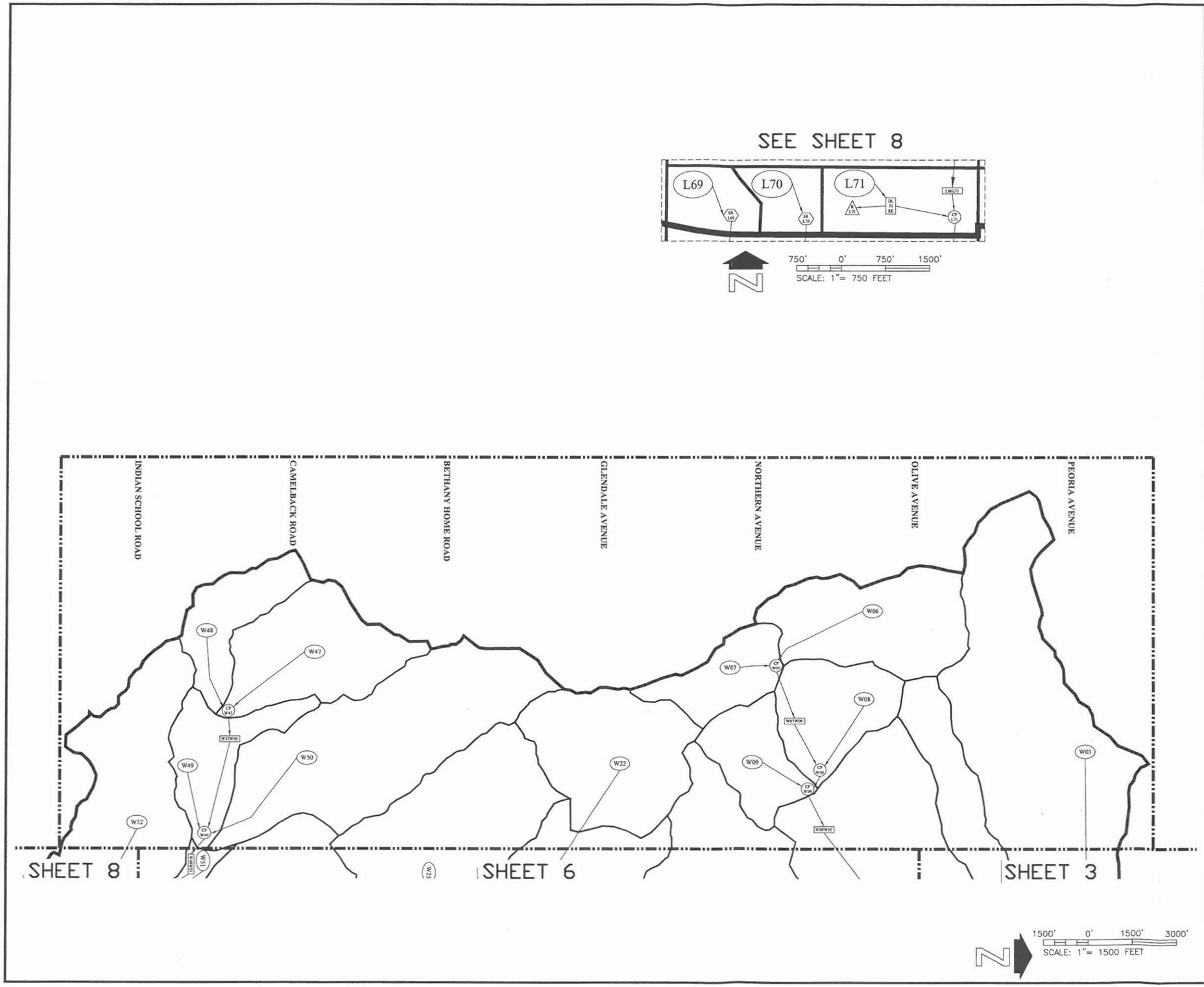

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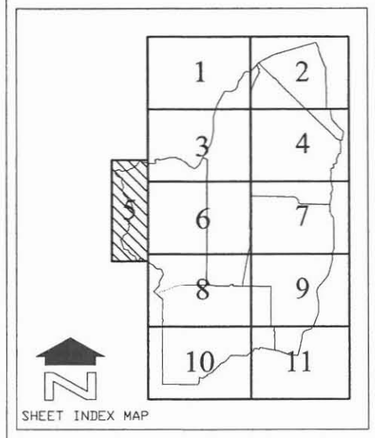

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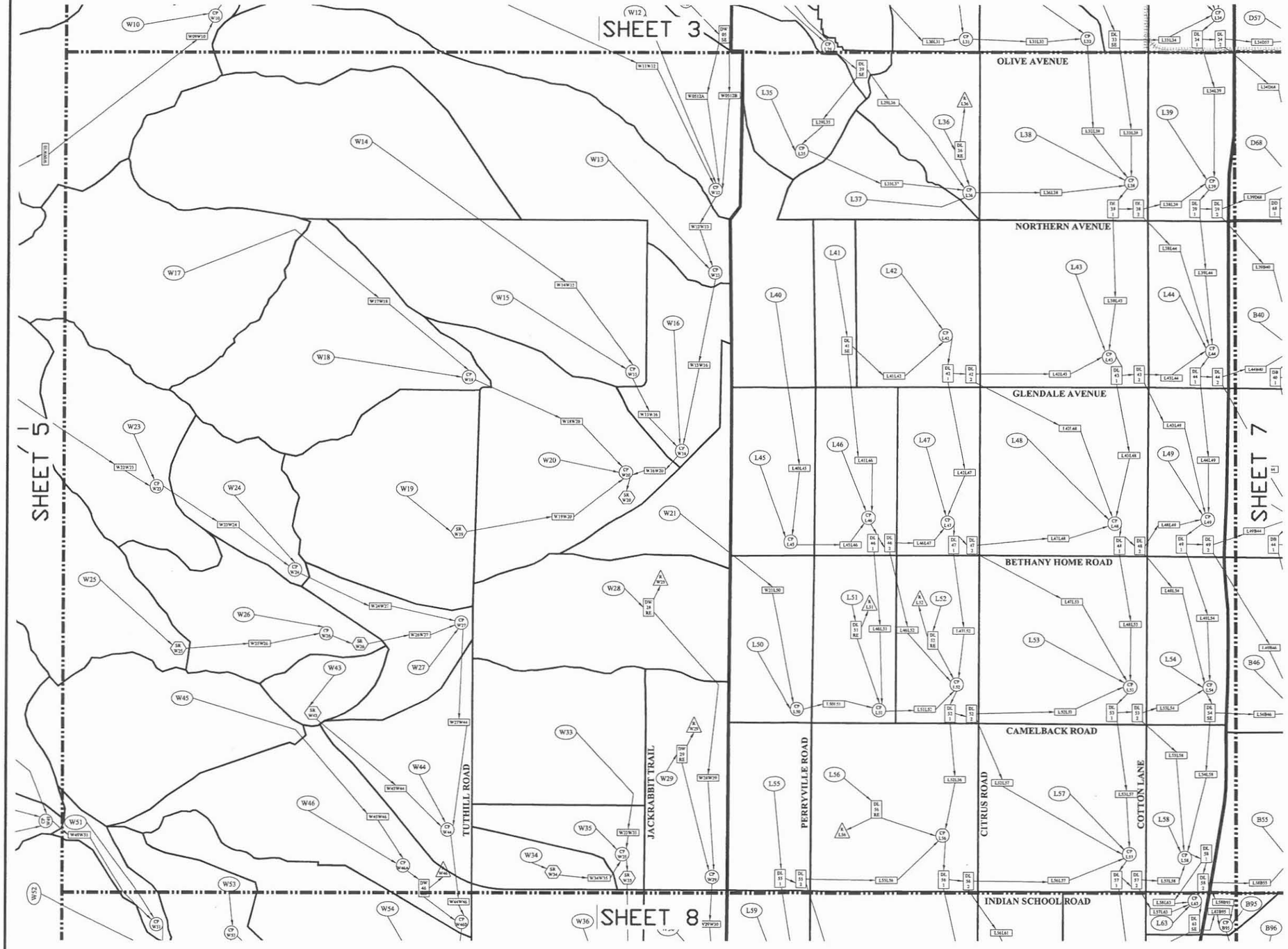

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- DW W## SW — DIVERSION LABEL
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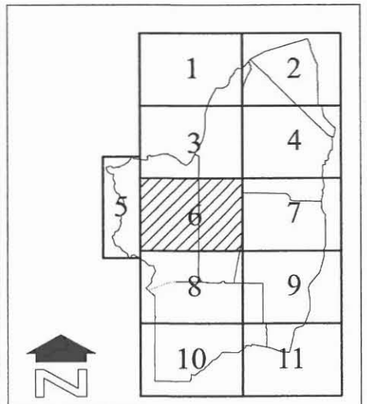

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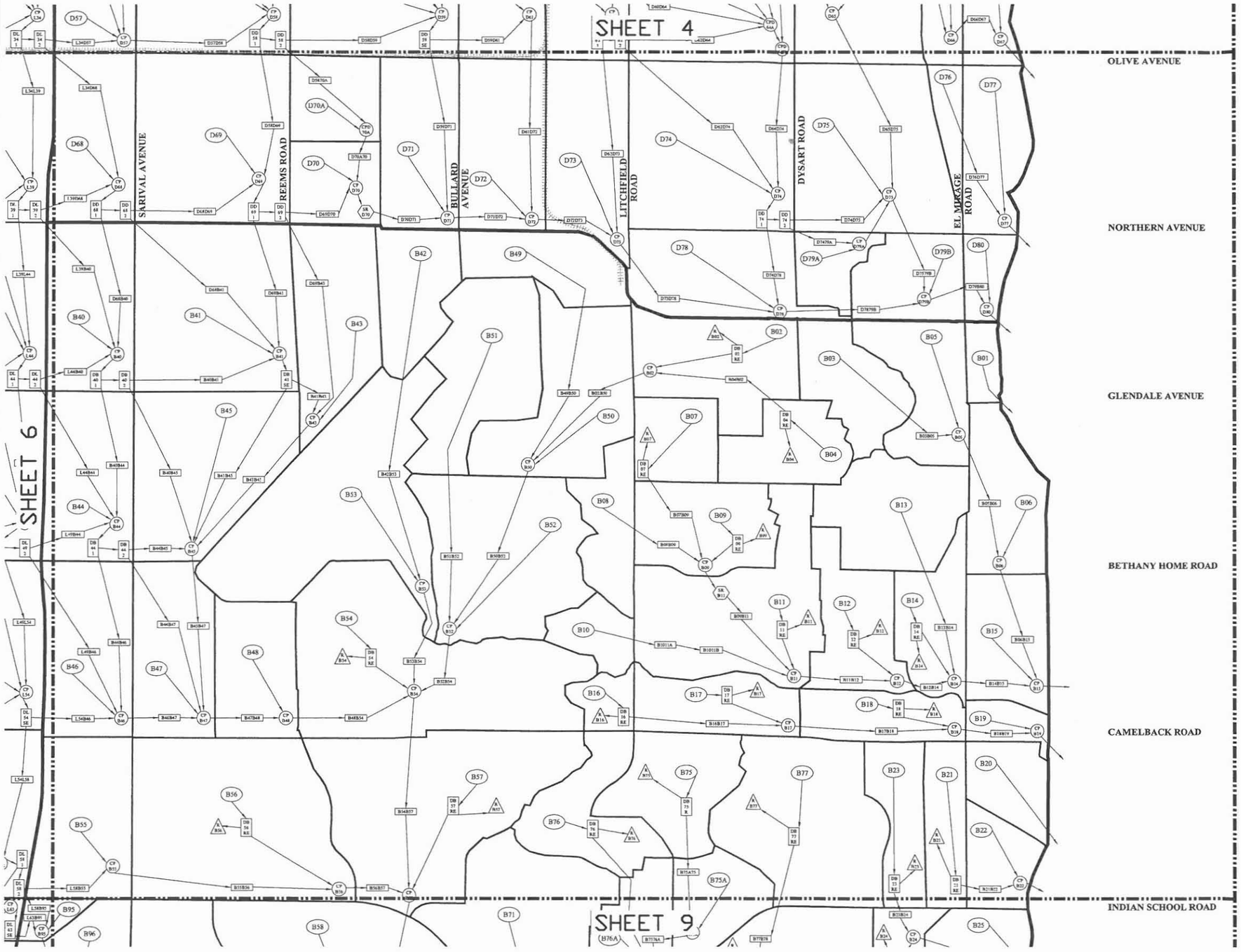

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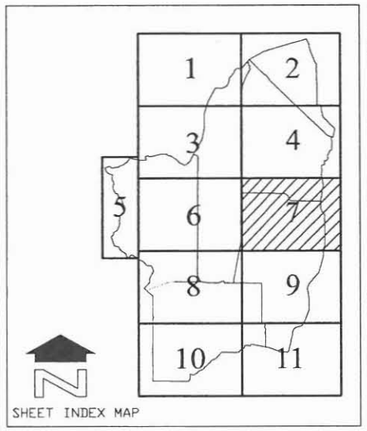

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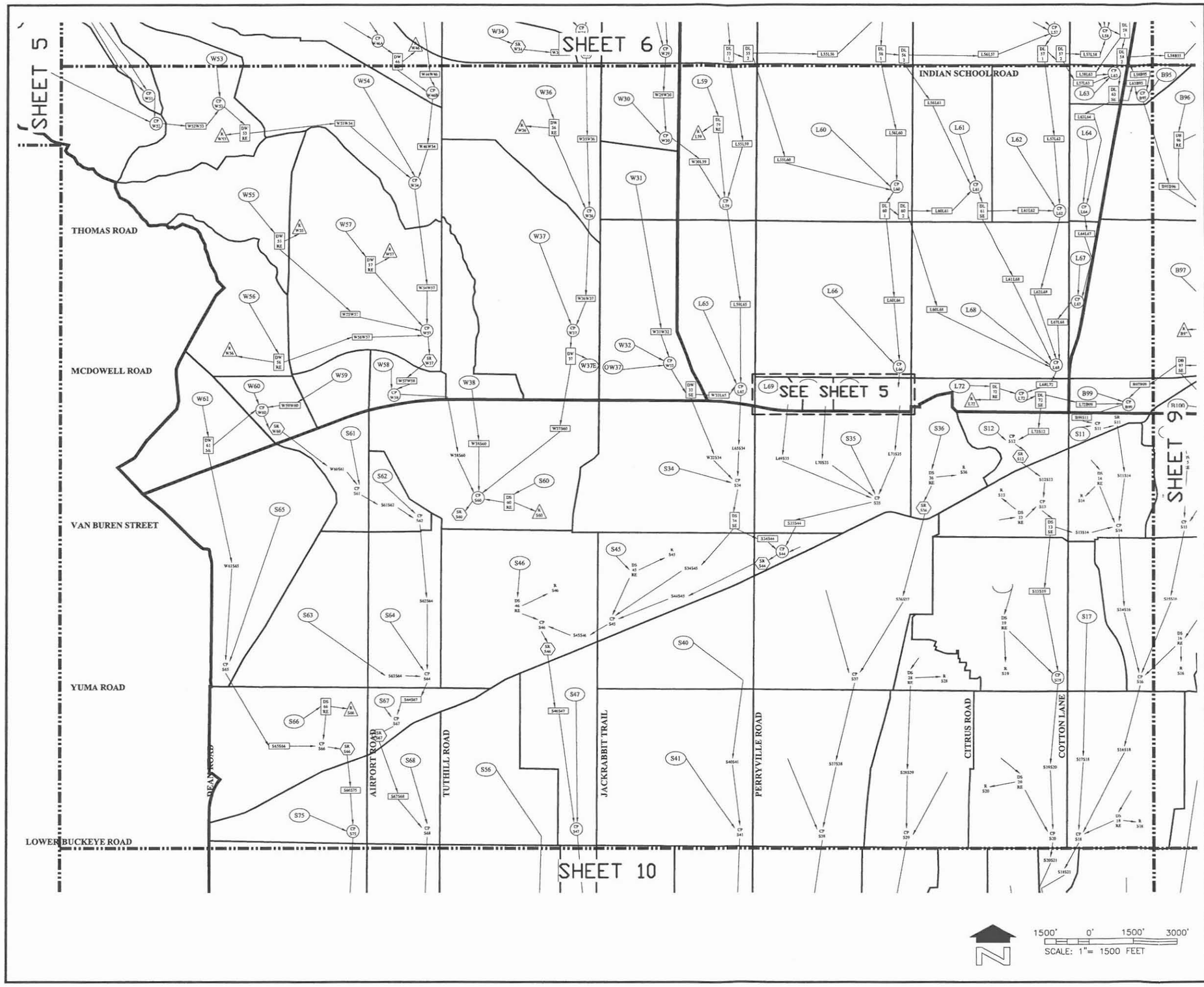

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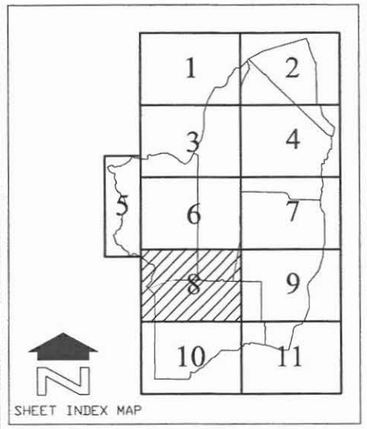

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FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

LOOP 303 WHITE TANKS AREA DRAINAGE
MASTER PLAN AREA UPDATE HYDROLOGIC ANALYSIS
CONTRACT NUMBER: FCD 2007C031

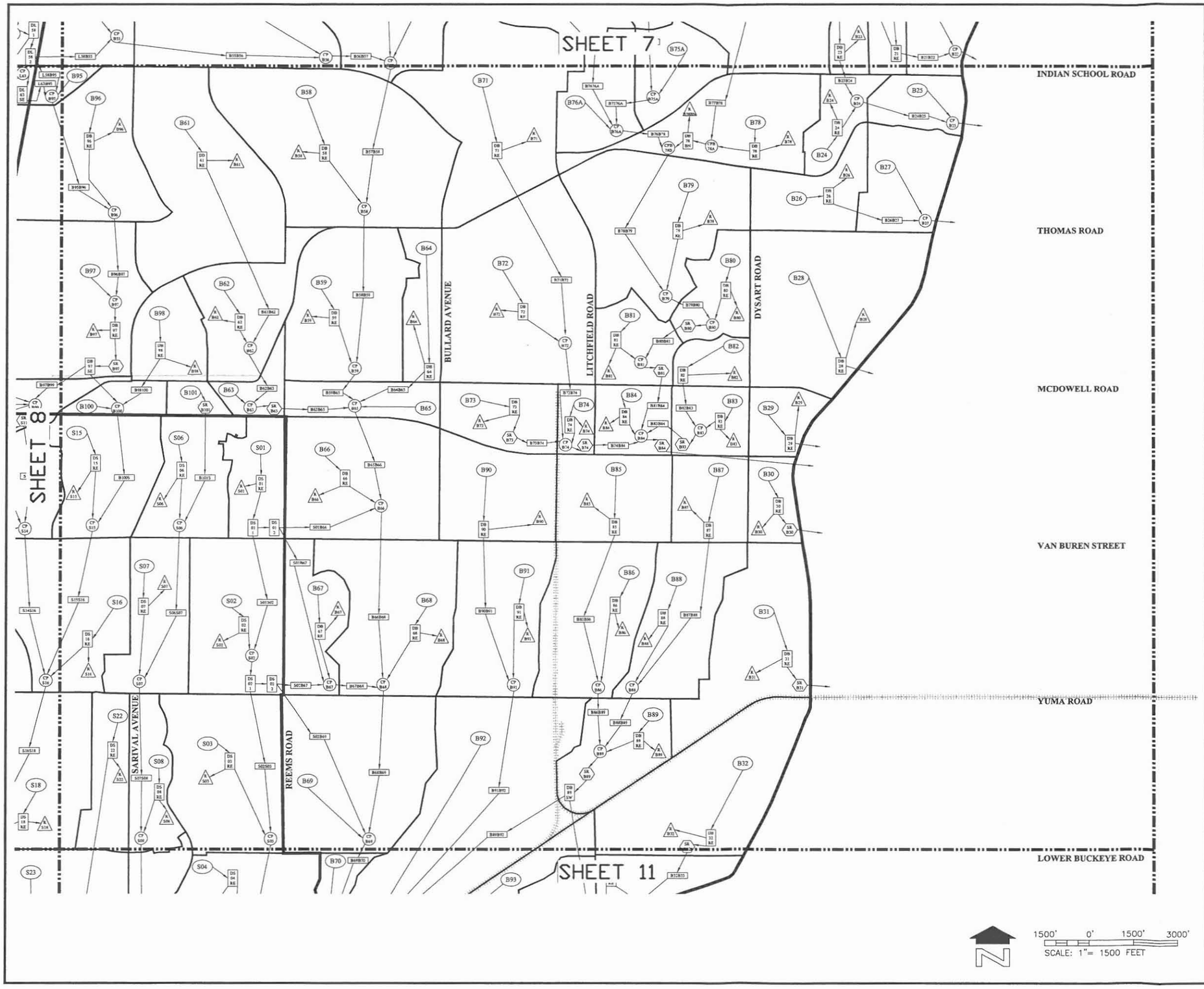
EXISTING CONDITIONS HYDROLOGY
DRAFT HEC-1 SCHEMATIC

HDR ENGINEERING, INC.
3200 East Camelback Road, Suite 350
PHOENIX, ARIZONA 85018-2311
(602) 522-7700

	BY	DATE
DESIGN	LP	06/09/09
DESIGN CHK.	LP	06/09/09
PLANS	JM/JG	06/09/09
PLANS CHK.	LP	06/09/09

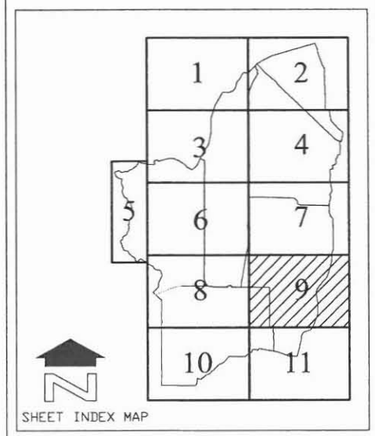
DRAFT_JM_090308

SHEET 8 OF 12



LEGEND

- HEC-1 REGION BOUNDARY
- HYDROLOGIC SUBBASIN BOUNDARY
- HYDROLOGIC SUBBASIN LABEL
- CONCENTRATION POINT LABEL
- ROUTE LABEL
- DIVERSION LABEL
- RETENTION LABEL
- STORAGE ROUTE LABEL
- MATCHLINE
- RAILROAD



SHEET INDEX MAP

HDR

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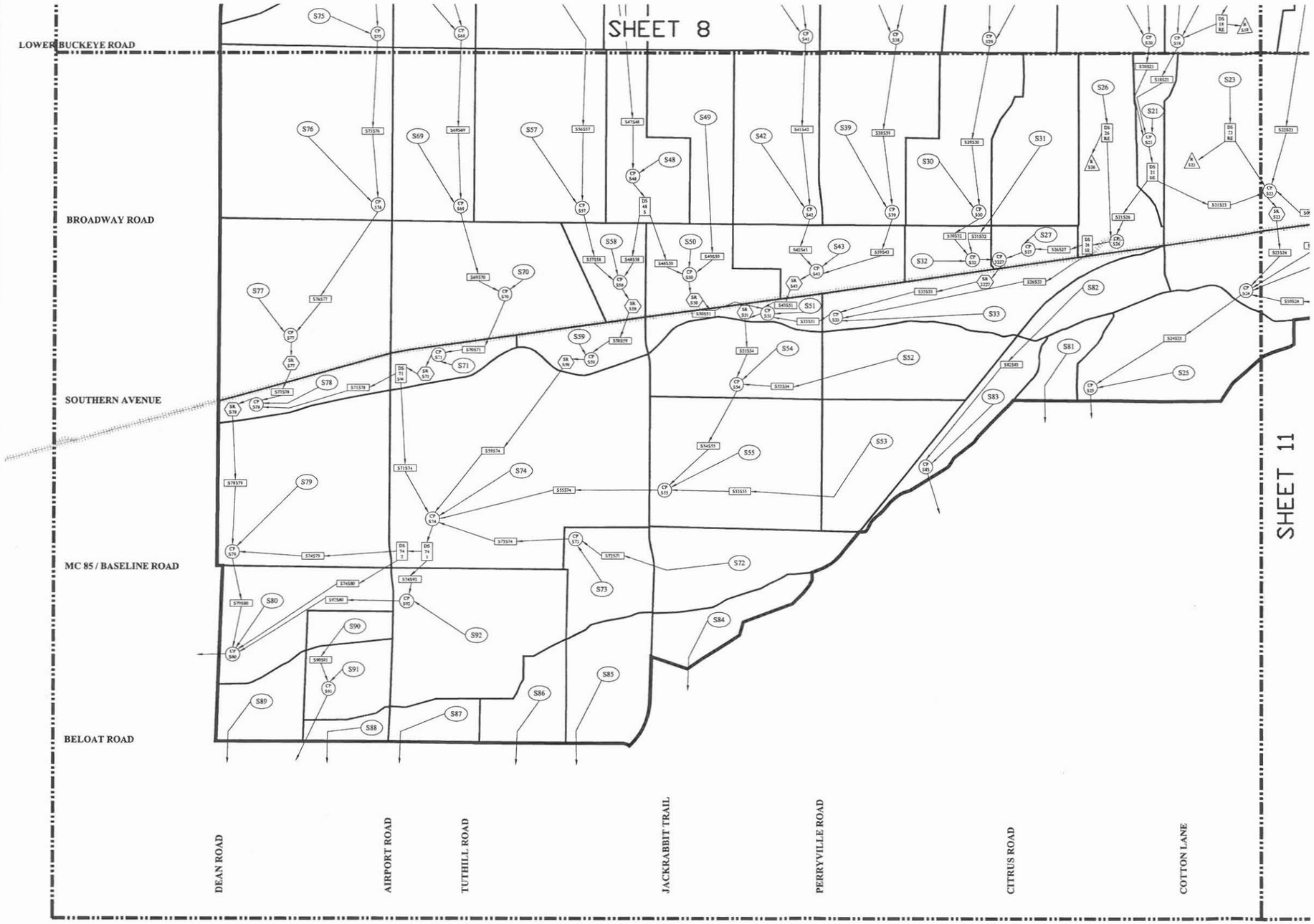

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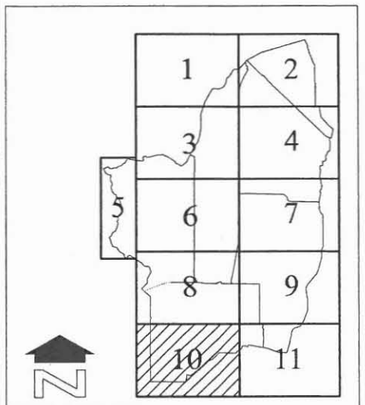

SHEET INDEX MAP

1500' 0' 1500' 3000'

SCALE: 1"= 1500 FEET

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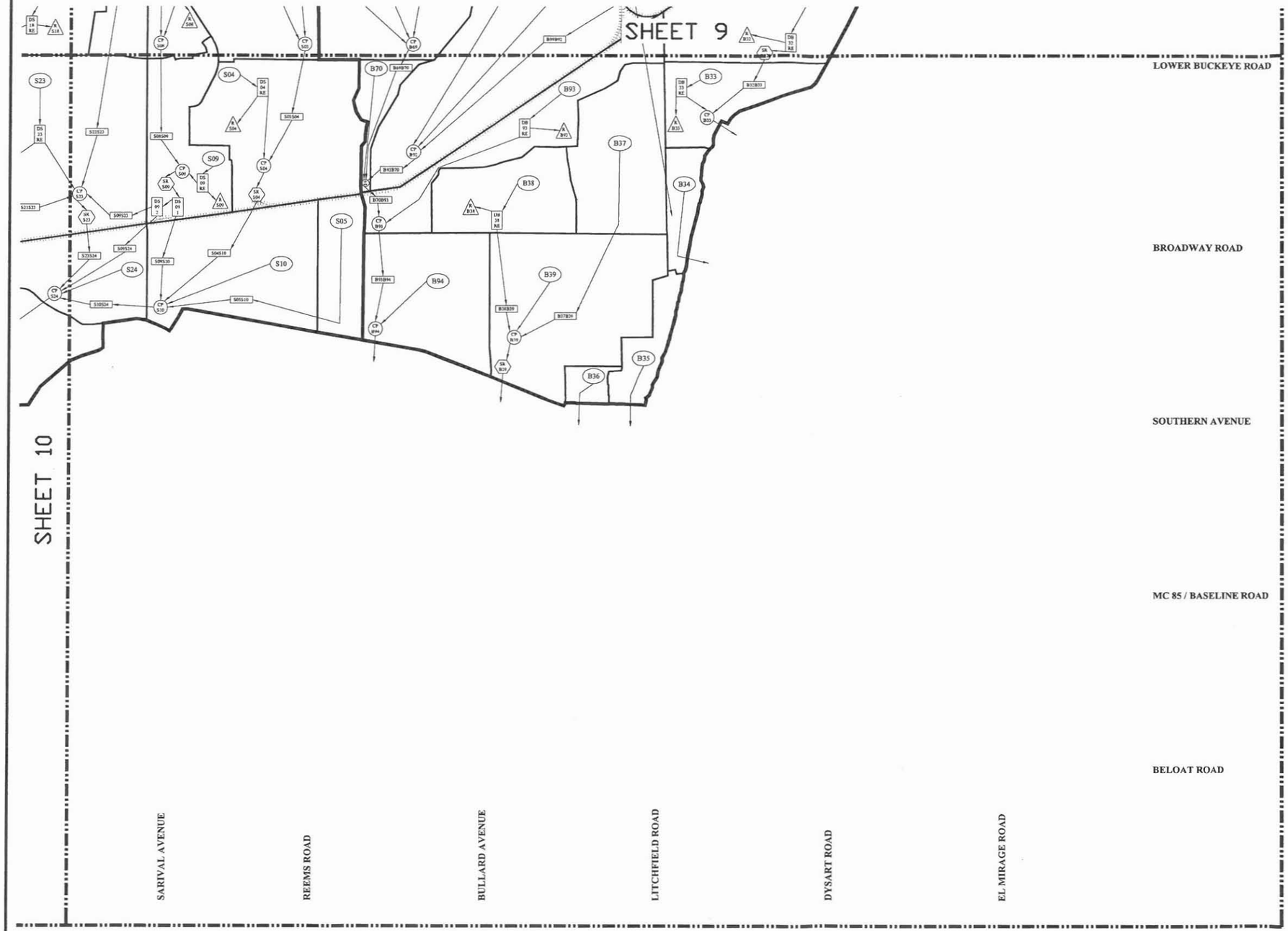
SHEET 10 OF 12



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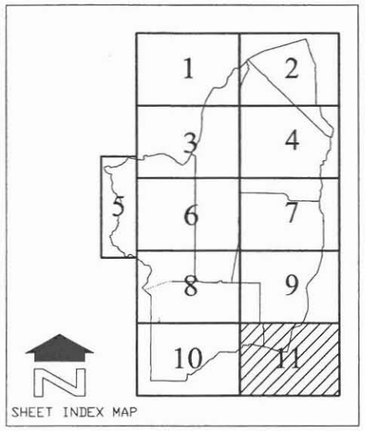

SHEET INDEX MAP

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1500' 0' 1500' 3000'
SCALE: 1"= 1500 FEET

LOOP 303 WHITE TANKS
AREA DRAINAGE MASTER PLAN UPDATE
AREA HYDROLOGIC ANALYSIS
CONTRACT NUMBER: FCD 2007C031
CAPITAL IMPROVEMENT PROJECT CONDITIONS
HYDROLOGY HEC-1 SCHEMATIC

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

AUTHORITY FOR STUDY

THE FLOOD CONTROL DISTRICT OF MARICOPA COUNTY (FCDMC) HAS CONTRACTED HDR TO PREPARE THIS STUDY UNDER THE CONTRACT NUMBER 2007C031. AND PROJECT CONTROL NUMBER 470.14.31.

PROJECT LOCATION

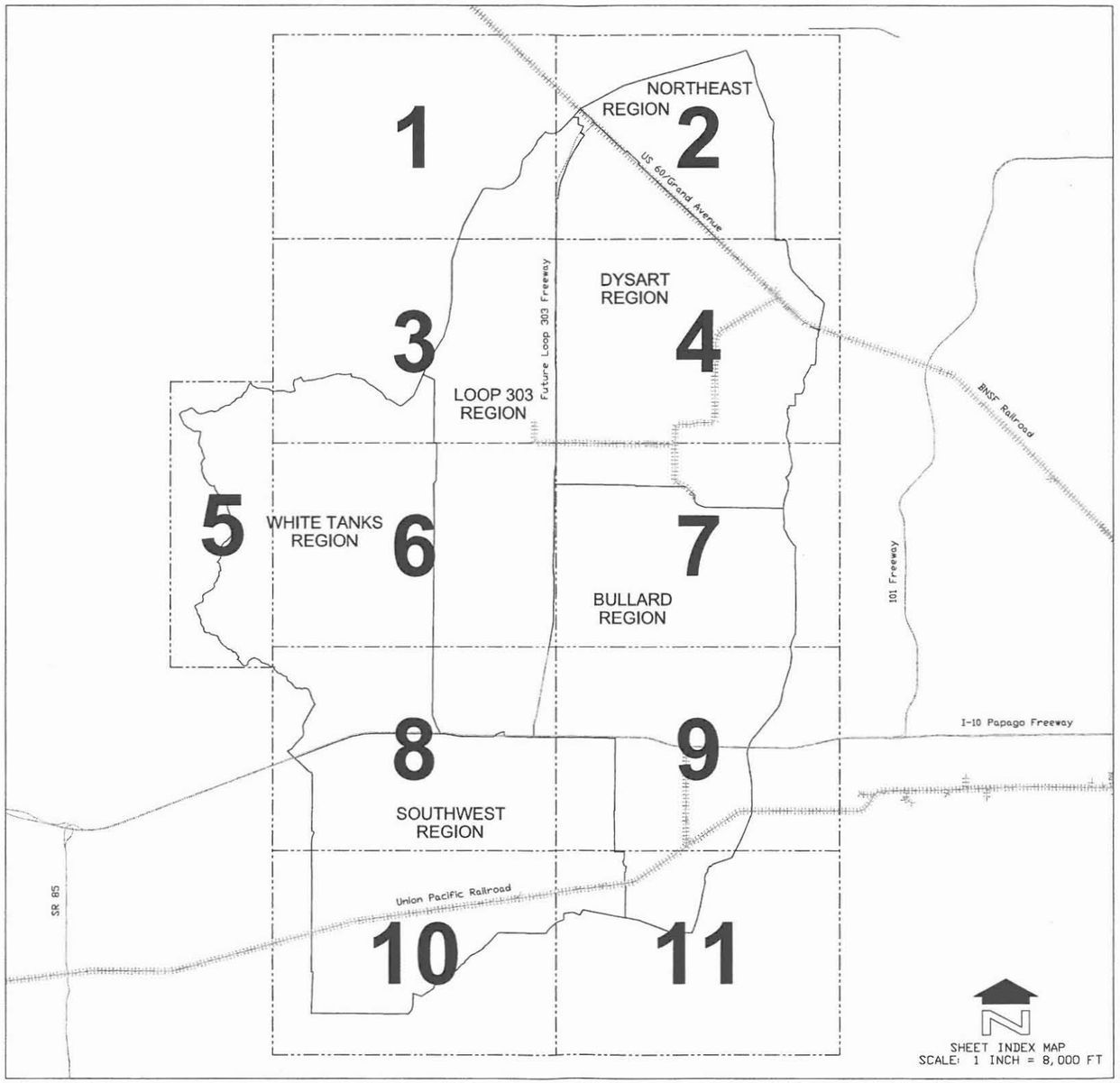
THE PROJECT SITE IS GENERALLY BOUNDED BY THE MCMICKEN DAM ON THE NORTH, AGUA FRIA RIVER ON THE EAST, THE GILA RIVER ON THE SOUTH AND THE WHITE TANK MOUNTAIN DIVIDE AND DEAN ROAD ON THE WEST. THE TOTAL ADMP AND WATERSHED AREA IS APPROXIMATELY 238 SQUARE MILES, WHICH INCLUDES UNINCORPORATED MARICOPA COUNTY AND PORTIONS OF AVONDALE, BUCKEYE, EL MIRAGE, GLENDALE, GOODYEAR, LITCHFIELD PARK, SURPRISE, AND LUKE AIR FORCE BASE.

SHEET INDEX

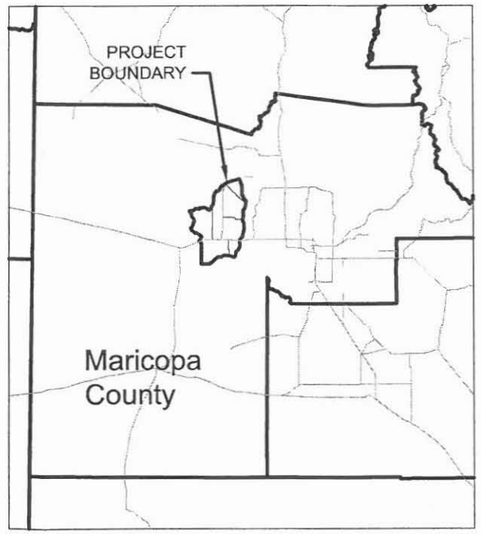
SHEET 01 – TUTHILL ROAD TO LOOP 303
PINNACLE PEAD ROAD TO BELL ROAD
SHEET 02 – LOOP 303 TO AGUA FRIA RIVER
HAPPY VALLEY PKWY TO BELL ROAD
SHEET 03 – DEAN ROAD ALIGNMENT TO LOOP 303
BELL ROAD TO OLIVE AVENUE
SHEET 04 – LOOP 303 TO AGUA FRIA RIVER
BELL ROAD TO OLIVE AVENUE
SHEET 05 – WHITE TANK MTN DIVIDE TO WATSON ROAD
PEORIA ROAD TO INDIAN SCHOOL ROAD
SHEET 06 – WATSON ROAD TO LOOP 303
OLIVE AVENUE TO INDIAN SCHOOL ROAD
SHEET 07 – LOOP 303 TO AGUA FRIA RIVER
OLIVE AVENUE TO INDIAN SCHOOL ROAD
SHEET 08 – DEAN ROAD TO LOOP 303
INDIAN SCHOOL ROAD TO LOWER BUCKEYE ROAD
SHEET 09 – LOOP 303 TO AGUA FRIA RIVER
INDIAN SCHOOL ROAD TO LOWER BUCKEYE ROAD
SHEET 10 – DEAN ROAD TO LOOP 303
LOWER BUCKEYE ROAD TO GILA RIVER
SHEET 11 – LOOP 303 TO AGUA FRIA RIVER
LOWER BUCKEYE ROAD TO GILA RIVER

ABBREVIATIONS

I – INTERSTATE
SR – STATE ROUTE



SHEET INDEX MAP
SCALE: 1 INCH = 8,000 FT



VICINITY MAP
SCALE: 1 INCH = 100,000 FT

JULY, 2009

HDR ENGINEERING, INC.
3200 East Camelback Road, Suite 350
PHOENIX, ARIZONA 85018-2311
(602) 522-7700

Existing with CIP Conditions

HEC-1 Concentration Point ID	100-yr, 24-hr Flow (cfs)	HEC-1 Concentration Point ID	100-yr, 24-hr Flow (cfs)	HEC-1 Concentration Point ID	100-yr, 24-hr Flow (cfs)	HEC-1 Concentration Point ID	100-yr, 24-hr Flow (cfs)	HEC-1 Concentration Point ID	100-yr, 24-hr Flow (cfs)	HEC-1 Concentration Point ID	100-yr, 24-hr Flow (cfs)
CP7874	484	CPB94	2327	CPD73A	184	CPL66	311	CPS48	297	CPW46A	2199
CPB02	257	CPB96	354	CPD74	316	CPL67	994	CPS50	462	CPW46B	3824
CPB05	521	CPB97	1001	CPD74A	337	CPL68	1306	CPS51	1008	CPW47	1236
CPB06	796	CPB99	117	CPD75	463	CPL69	1038	CPS54	747	CPW49	2575
CPB09	887	CPD02	617	CPD77	629	CPL70	1034	CPS55	701	CPW51	2531
CPB100	141	CPD04	1062	CPD78A	263	CPL71	1179	CPS57	396	CPW52	3510
CPB11	1190	CPD05	337	CPD78B	1062	CPL72	2078	CPS58	417	CPW53	3427
CPB12	1501	CPD07	348	CPD79B	1197	CPN01	479	CPS59	399	CPW54	6696
CPB14	1936	CPD10	637	CPD80	1197	CPN02	421	CPS60	6609	CPW57	7485
CPB15	2450	CPD12	272	CPL03	60	CPN03B	482	CPS61	365	CPW58	7299
CPB17	563	CPD13	1138	CPL04	17	CPN04	1123	CPS62	490	CPW60	768
CPB18	628	CPD14	980	CPL05	636	CPN05	1084	CPS64	1369		
CPB19	561	CPD15	417	CPL07	50	CPN06	1016	CPS65	773		
CPB22	389	CPD16	258	CPL08	110	CPN09	1689	CPS66	567		
CPB24	439	CPD18	27	CPL09	574	CPN11	962	CPS67	1478		
CPB25	352	CPD19	416	CPL11	440	CPN13	1531	CPS68	1489		
CPB27	533	CPD20	334	CPL12	492	CPN15	3749	CPS69	1501		
CPB33	241	CPD21	327	CPL13	633	CPN17	4912	CPS70	1651		
CPB39	387	CPD22	79	CPL13B	245	CPN18	1797	CPS71	1584		
CPB40	350	CPD23	130	CPL15	554	CPN21	381	CPS73	245		
CPB41	581	CPD24	343	CPL16	583	CPN22	311	CPS74	1006		
CPB43	133	CPD25	309	CPL17	559	CPN24	887	CPS75	560		
CPB44	248	CPD26	308	CPL18	618	CPN25	832	CPS76	633		
CPB45	680	CPD27	491	CPL19	1180	CPN26	932	CPS77	748		
CPB46	2371	CPD28	475	CPL22	56	CPRMS	494	CPS78	1528		
CPB47	2656	CPD29	216	CPL24	943	CPS02	225	CPS79	490		
CPB48	2737	CPD30	712	CPL26	998	CPS03	68	CPS80	895		
CPB50	1332	CPD31	206	CPL27	1735	CPS04	341	CPS81A	369		
CPB51	2307	CPD33	210	CPL29	456	CPS06	42	CPS82	369		
CPB52	2925	CPD34	166	CPL31	114	CPS07	33	CPS83	84		
CPB53	862	CPD35	119	CPL32	393	CPS08	29	CPS91	231		
CPB54	2867	CPD36	220	CPL34	984	CPS09	84	CPS92	467		
CPB56	346	CPD38	170	CPL34B	1242	CPS10	263	CPW01	250		
CPB57	2671	CPD39	356	CPL35	552	CPS11	157	CPW02	654		
CPB58	2684	CPD40	215	CPL36	457	CPS13	599	CPW04	2357		
CPB59	2863	CPD42	469	CPL38	911	CPS14A	77	CPW05	2514		
CPB62	39	CPD46	735	CPL39	932	CPS14B	315	CPW07	1216		
CPB63	111	CPD47	88	CPL39A	1291	CPS15	439	CPW08	1605		
CPB65A	2883	CPD48	216	CPL39B	1177	CPS16	250	CPW09	2066		
CPB65B	1885	CPD49	724	CPL42	668	CPS18	302	CPW10	3122		
CPB66	1996	CPD50	317	CPL43	1075	CPS19	236	CPW11	3979		
CPB67	241	CPD53	355	CPL44	1570	CPS20	628	CPW12	5628		
CPB68	2101	CPD54	319	CPL45	781	CPS23	29	CPW13	6092		
CPB69	2141	CPD57	173	CPL46	1172	CPS24	242	CPW15	2177		
CPB70	2275	CPD58	700	CPL47	1444	CPS25	469	CPW16	6978		
CPB72	1026	CPD59	286	CPL48	766	CPS26	663	CPW18	1438		
CPB74	1003	CPD60	175	CPL49	2208	CPS26A	161	CPW20	8089		
CPB75A	413	CPD61	105	CPL50	514	CPS27	369	CPW21A	163		
CPB76A	773	CPD63	752	CPL51	829	CPS29	303	CPW23	2264		
CPB78A	948	CPD64	293	CPL52	1059	CPS30	441	CPW24	2718		
CPB78B	1022	CPD64A	306	CPL53	1460	CPS31	1212	CPW26	810		
CPB79	1028	CPD65	467	CPL54	2276	CPS32	472	CPW27	2984		
CPB80	962	CPD66	529	CPL56	345	CPS37	472	CPW28A	620		
CPB81	896	CPD67	650	CPL57	790	CPS38	623	CPW29	489		
CPB83	449	CPD69	182	CPL58	967	CPS39	659	CPW30	463		
CPB84	942	CPD69A	714	CPL59	398	CPS41	446	CPW32	575		
CPB86	635	CPD70	748	CPL60	259	CPS42	468	CPW33	1111		
CPB88	714	CPD71	267	CPL61	193	CPS43	1044	CPW35	1177		
CPB89	1268	CPD71A	257	CPL62	206	CPS44	599	CPW36	1341		
CPB91	321	CPD72	458	CPL63	986	CPS45	292	CPW37	1890		
CPB92	2009	CPD72A	327	CPL64	994	CPS46	277	CPW38	1103		
CPB93	2330	CPD73	573	CPL65	1048	CPS47	206	CPW44	3047		

Future with CIP Conditions

HEC-1 Concentration Point ID	100-yr, 24-hr Flow (cfs)	HEC-1 Concentration Point ID	100-yr, 24-hr Flow (cfs)	HEC-1 Concentration Point ID	100-yr, 24-hr Flow (cfs)	HEC-1 Concentration Point ID	100-yr, 24-hr Flow (cfs)	HEC-1 Concentration Point ID	100-yr, 24-hr Flow (cfs)	HEC-1 Concentration Point ID	100-yr, 24-hr Flow (cfs)
CP7874	128	CPB94	1491	CPD73A	303	CPL66	479	CPS48	506	CPW46B	3302
CPB02	205	CPB96	615	CPD74	174	CPL67	321	CPS50	321	CPW47	1348
CPB05	537	CPB97	1001	CPD74A	257	CPL68	1158	CPS51	169	CPW49	2815
CPB06	620	CPB99	286	CPD75	254	CPL69	678	CPS54	143	CPW51	2771
CPB09	614	CPD02	617	CPD77	665	CPL70	677	CPS55	274	CPW52	3959
CPB100	265	CPD04	1062	CPD78A	117	CPL71	873	CPS57	786	CPW53	3829
CPB11	1160	CPD05	337	CPD78B	747	CPL72	1621	CPS58	575	CPW54	6004
CPB12	1383	CPD07	348	CPD79B	491	CPN01	156	CPS59	488	CPW57	5709
CPB14	1349	CPD10	500	CPD80	514	CPN02	72	CPS60	4620	CPW58	5354
CPB15	1707	CPD12	258	CPL03	60	CPN03B	449	CPS61	171	CPW60	77
CPB17	552	CPD13	220	CPL04	17	CPN04	1067	CPS62	134		
CPB18	429	CPD14	188	CPL05	636	CPN05	1065	CPS64	818		
CPB19	296	CPD15	423	CPL07	37	CPN06	981	CPS65	728		
CPB22	396	CPD16	263	CPL08	36	CPN09	1689	CPS66	270		
CPB24	414	CPD18	22	CPL09	574	CPN11	962	CPS67	896		
CPB25	361	CPD19	437	CPL11	439	CPN13	1531	CPS68	869		
CPB27	533	CPD20	291	CPL12	385	CPN15	3744	CPS69	816		
CPB33	4	CPD21	244	CPL13	502	CPN17	4903	CPS70	762		
CPB39	10	CPD22	37	CPL13B	245	CPN18	1797	CPS71	702		
CPB40	681	CPD23	38	CPL15	0	CPN21	366	CPS73	366		
CPB41	1042	CPD24	64	CPL16	0	CPN22	307	CPS74	720		
CPB43	215	CPD25	69	CPL17	0	CPN24	911	CPS75	244		
CPB44	223	CPD26	95	CPL18	44	CPN25	911	CPS76	320		
CPB45	855	CPD27	491	CPL19	511	CPN26	801	CPS77	687		
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CPB48	1586	CPD30	594	CPL26	518	CPS03	18	CPS80	449		
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CPB51	2353	CPD33	160	CPL29	57	CPS06	87	CPS82	190		
CPB52	1967	CPD34	67	CPL31	56	CPS07	69	CPS83	190		
CPB53	982	CPD35	3	CPL32	458	CPS08	62	CPS91	328		
CPB54	1802	CPD36	63	CPL34	473	CPS09	58	CPS92	386		
CPB56	62	CPD38	6	CPL34B	517	CPS10	18	CPW01	150		
CPB57	1633	CPD39	67	CPL35	10	CPS11	258	CPW02	454		
CPB58	1563	CPD40	5	CPL36	14	CPS13	197	CPW04	3313		
CPB59	1492	CPD42	345	CPL38	302	CPS14A	0	CPW05	3406		
CPB62	39	CPD46	573	CPL39	488	CPS14B	0	CPW07	1797		
CPB63	45	CPD47	74	CPL39A	549	CPS15	171	CPW08	2276		
CPB65A	1498	CPD48	74	CPL39B	230	CPS16	125	CPW09	2952		
CPB65B	1436	CPD49	724	CPL42	668	CPS18	89	CPW10	4343		
CPB66	1402	CPD50	11	CPL43	1075	CPS19	199	CPW11	5537		
CPB67	18	CPD53	174	CPL44	1122	CPS20	209	CPW12	7433		
CPB68	1311	CPD54	335	CPL45	16	CPS23	39	CPW13	8064		
CPB69	1268	CPD57	277	CPL46	568	CPS24	27	CPW15	1701		
CPB70	2040	CPD58	509	CPL47	1022	CPS25	190	CPW16	8530		
CPB72	1146	CPD59	279	CPL48	1006	CPS26	209	CPW18	902		
CPB74	980	CPD60	304	CPL49	1530	CPS26A	203	CPW20	8637		
CPB75A	413	CPD61	87	CPL50	7	CPS27	190	CPW21A	100		
CPB76A	773	CPD63	519	CPL51	126	CPS29	411	CPW23	2738		
CPB78A	886	CPD64	127	CPL52	325	CPS30	243	CPW24	3131		
CPB78B	960	CPD64A	10	CPL53	617	CPS31	276	CPW26	1108		
CPB79	1058	CPD65	243	CPL54	1476	CPS32	212	CPW27	3252		
CPB80	883	CPD66	441	CPL56	38	CPS37	331	CPW28A	630		
CPB81	708	CPD67	550	CPL57	96	CPS38	148	CPW29	0		
CPB83	476	CPD69	28	CPL58	305	CPS39	115	CPW30	354		
CPB84	742	CPD69A	493	CPL59	239	CPS41	172	CPW32	619		
CPB86	927	CPD70	457	CPL60	149	CPS42	180	CPW33	942		
CPB88	657	CPD71	191	CPL61	33	CPS43	232	CPW35	773		
CPB89	1292	CPD71A	202	CPL62	26	CPS44	551	CPW36	812		
CPB91	10	CPD72	258	CPL63	313	CPS45	361	CPW37	1155		
CPB92	2029	CPD72A	257	CPL64	322	CPS46	311	CPW44	2785		
CPB93	1779	CPD73	243	CPL65	683	CPS47	334	CPW46A	2053		

ONE COMPANY | *Many Solutions*™

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FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

LOOP 303 WHITE TANKS AREA DRAINAGE
MASTER PLAN AREA UPDATE HYDROLOGIC ANALYSIS
CONTRACT NUMBER: FCD 2007C031

CAPITAL IMPROVEMENT PROJECT
CONDITIONS HYDROLOGY
DRAFT HEC-1 SCHEMATIC

HDR ENGINEERING, INC.
3200 East Camelback Road, Suite 350
PHOENIX, ARIZONA 85018-2311
(602) 522-7700

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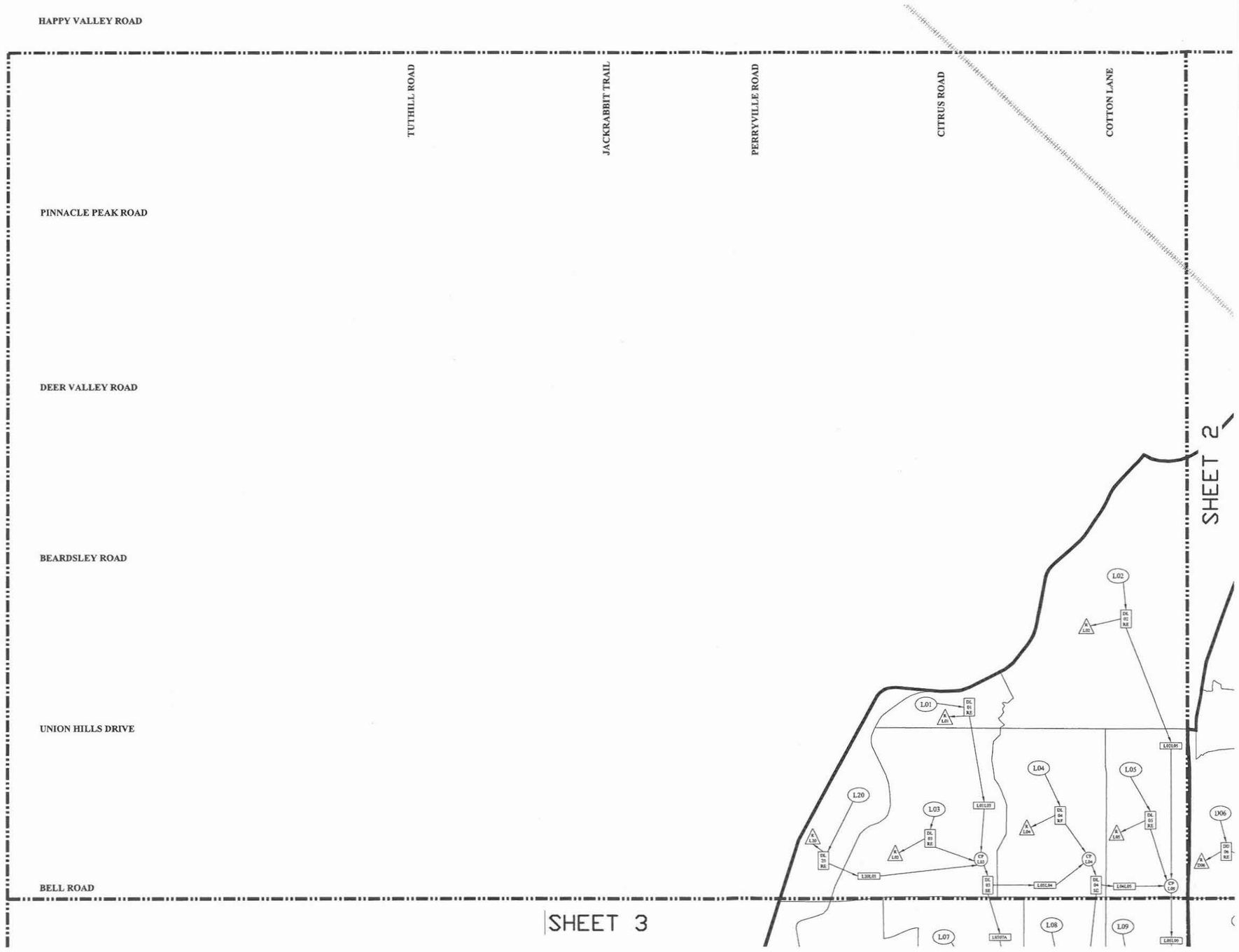

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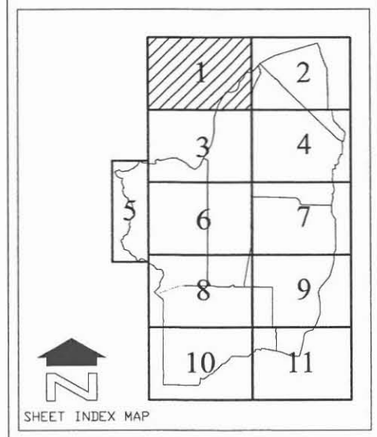

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FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

LOOP 303 WHITE TANKS AREA DRAINAGE
MASTER PLAN AREA UPDATE HYDROLOGIC ANALYSIS
CONTRACT NUMBER: FCD 2007C031

CAPITAL IMPROVEMENT PROJECT
CONDITIONS HYDROLOGY
DRAFT HEC-1 SCHEMATIC

HDR ENGINEERING, INC.
3200 East Camelback Road, Suite 350
PHOENIX, ARIZONA 85018-2311
(602) 522-7700

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DESIGN CHK.	LP	06/10/09
PLANS	JM/JG	06/10/09
PLANS CHK.	LP	06/10/09

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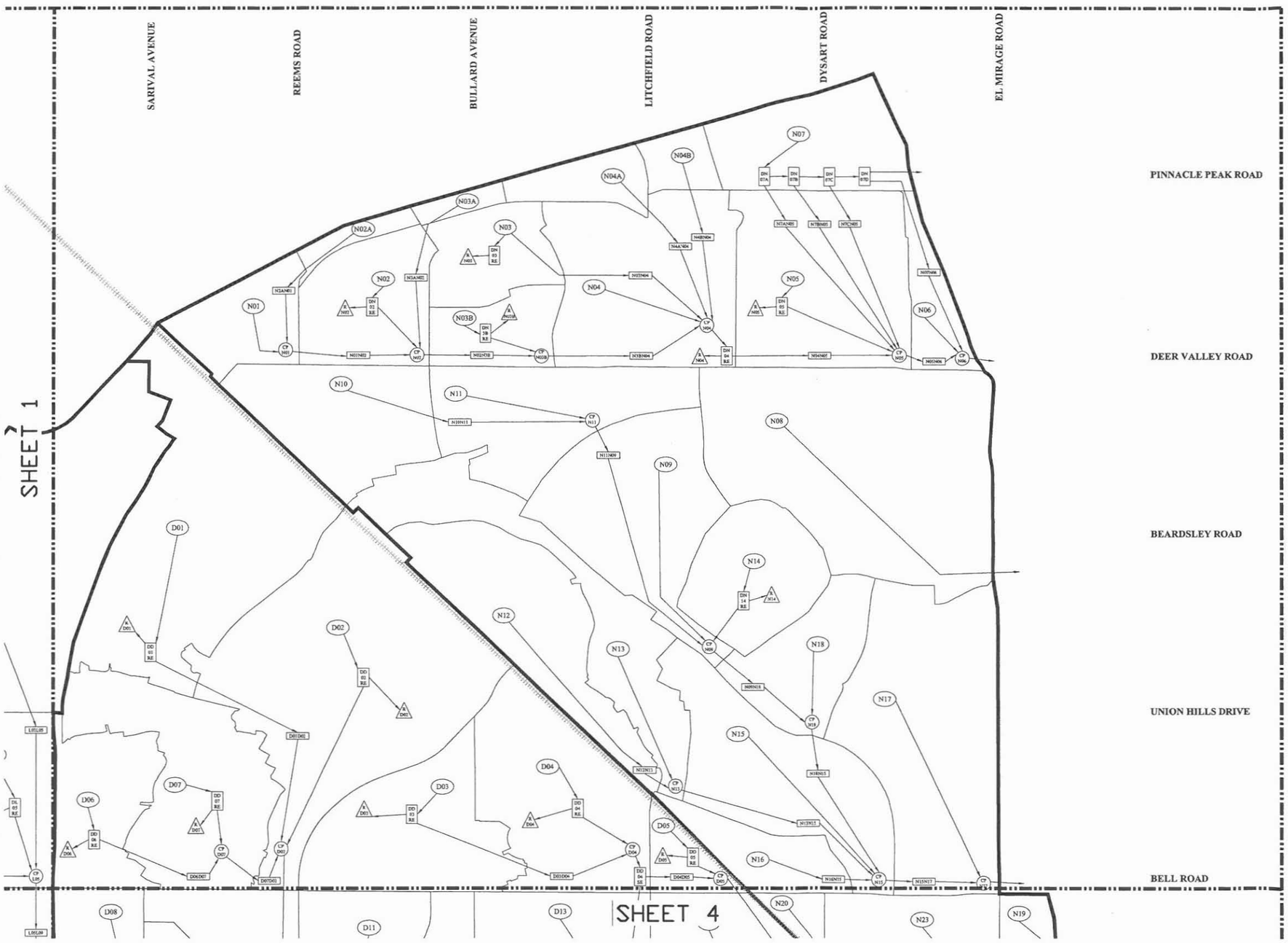
1500' 0' 1500' 3000'

SCALE: 1"= 1500 FEET



1500' 0' 1500' 3000'

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LEGEND

- HEC-1 REGION BOUNDARY
- HYDROLOGIC SUBBASIN BOUNDARY
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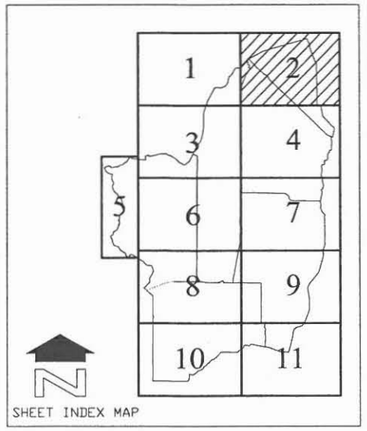
- MATCHLINE
- RAILROAD



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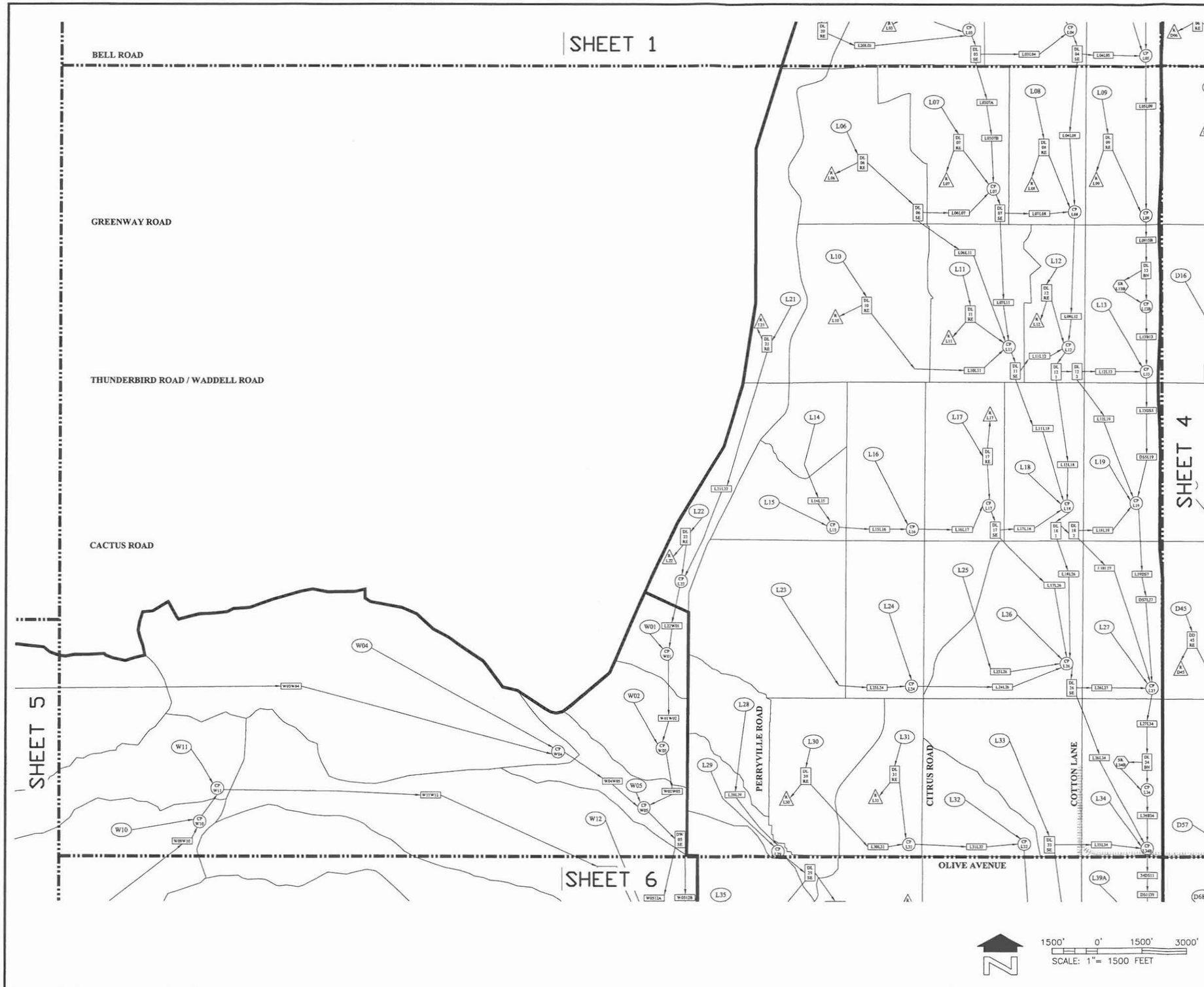

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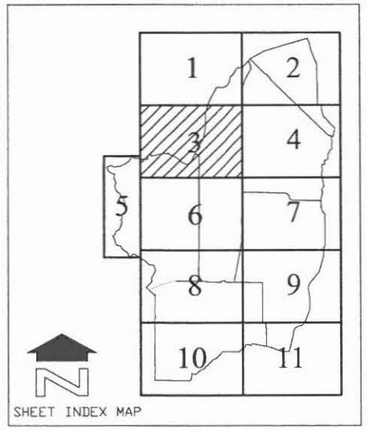

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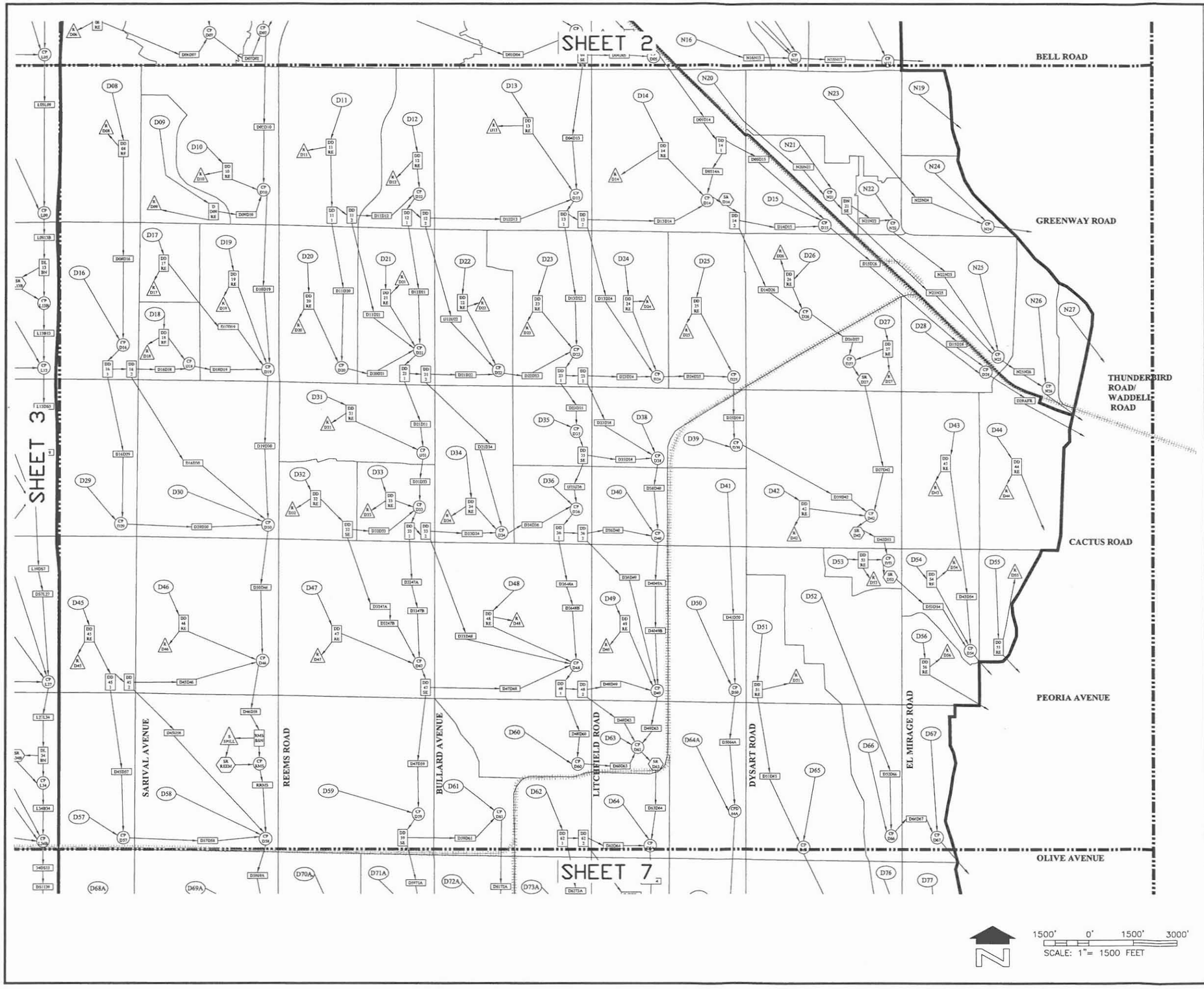

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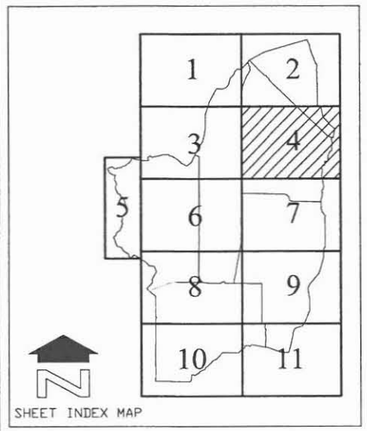

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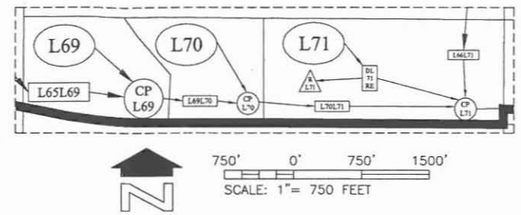

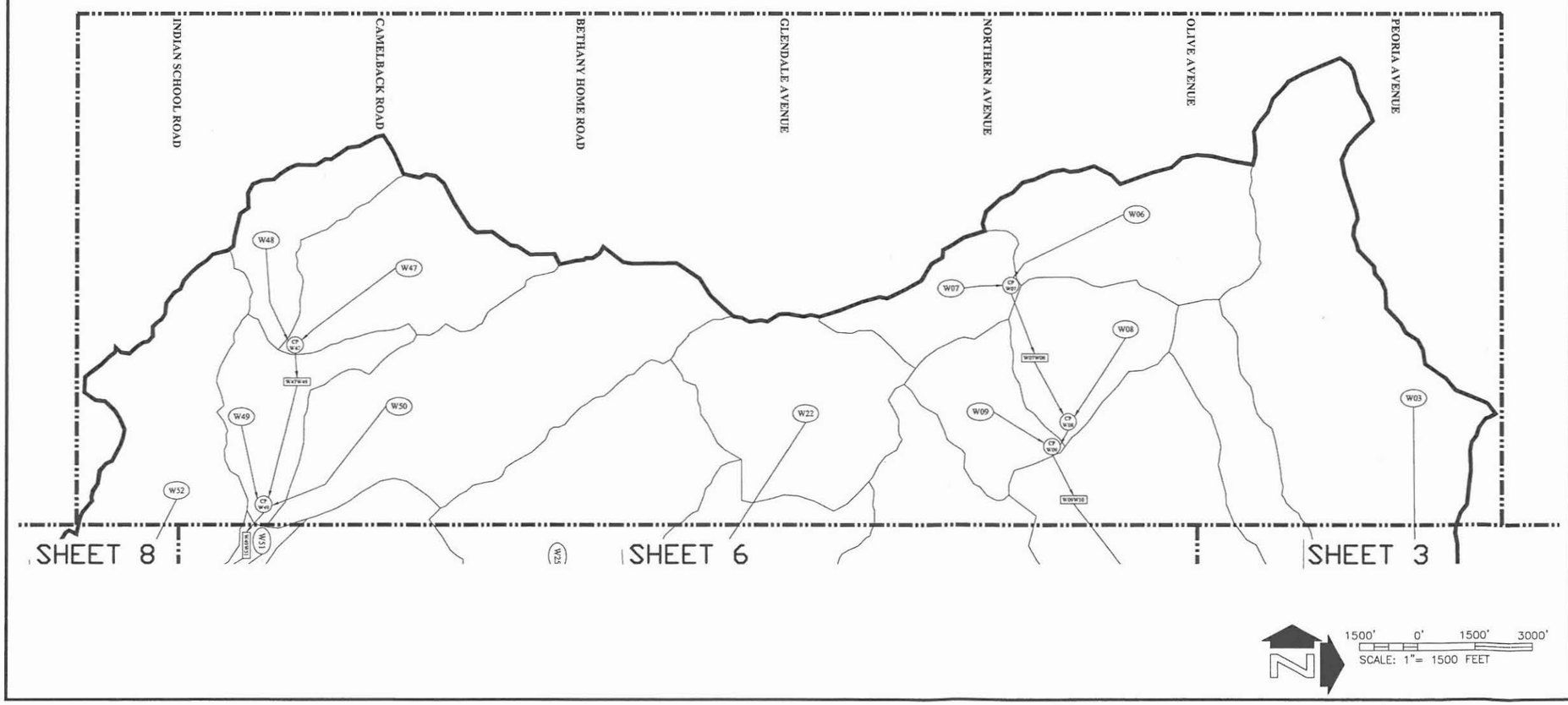

LEGEND

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- HYDROLOGIC SUBBASIN LABEL
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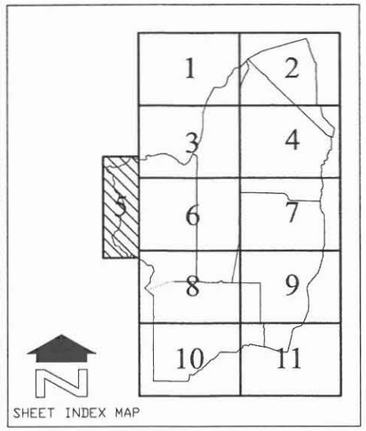

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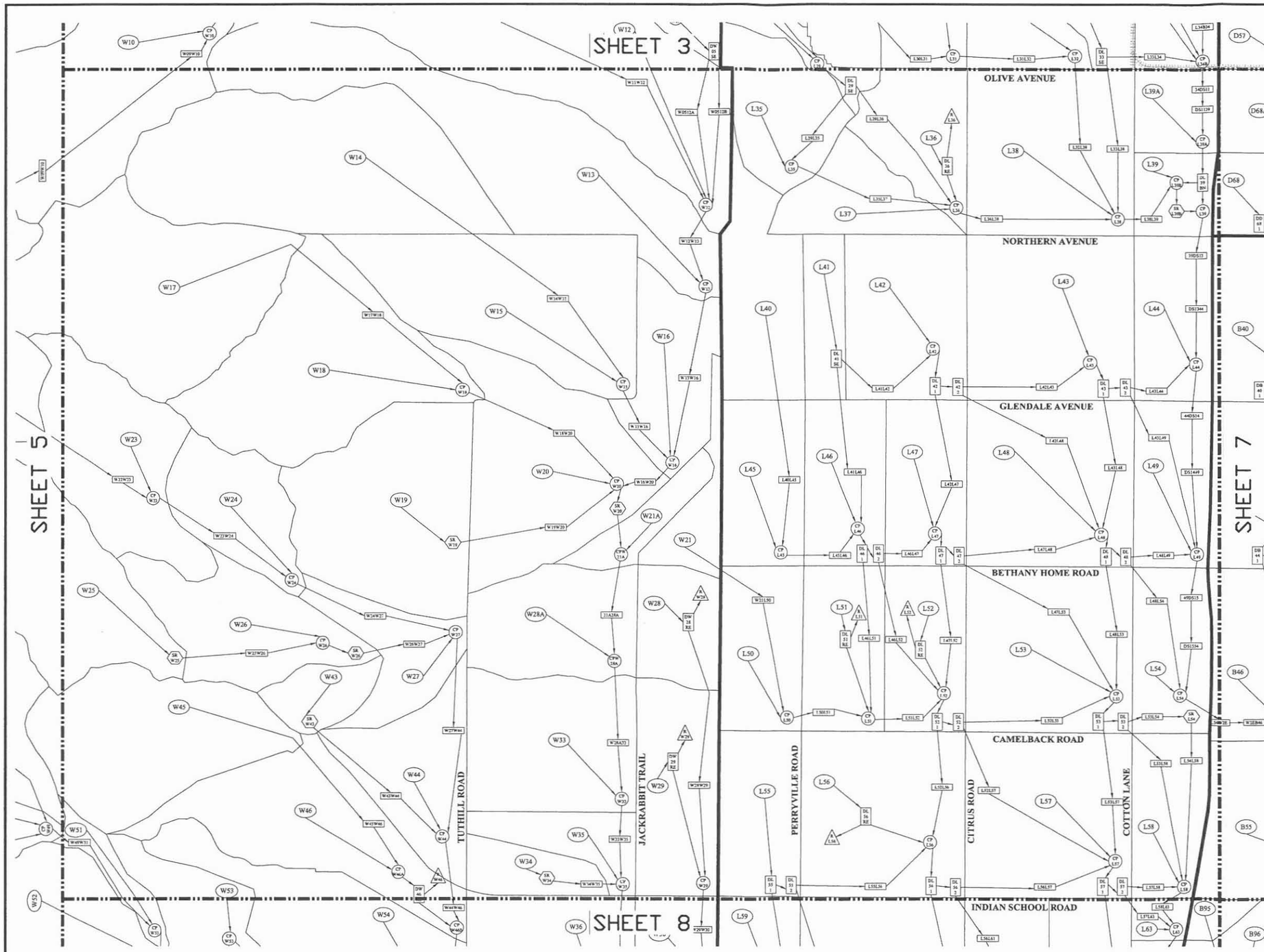

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- W## — HYDROLOGIC SUBBASIN LABEL
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- DIV ## SW — DIVERSION LABEL
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- SR W## — STORAGE ROUTE LABEL
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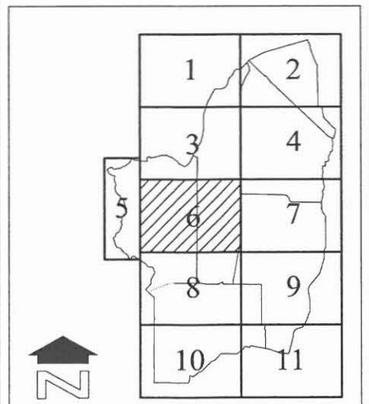
- RAILROAD



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Flood Control District of Maricopa County

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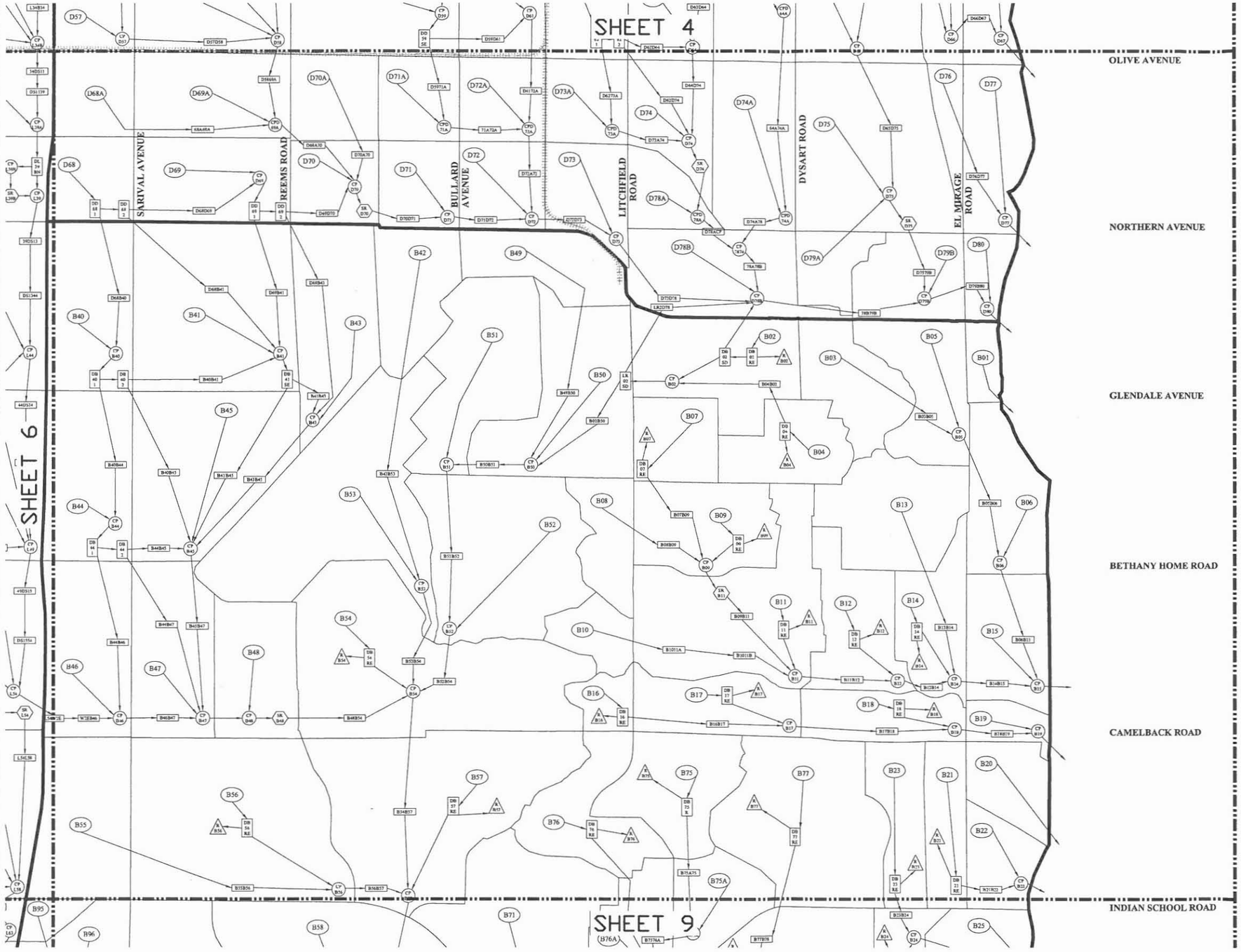

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- CP W## — CONCENTRATION POINT LABEL
- WWW## — ROUTE LABEL
- DIV W## SR — DIVERSION LABEL
- A W## — RETENTION LABEL
- SR W## — STORAGE ROUTE LABEL
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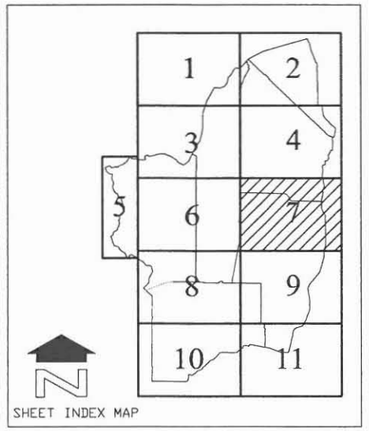

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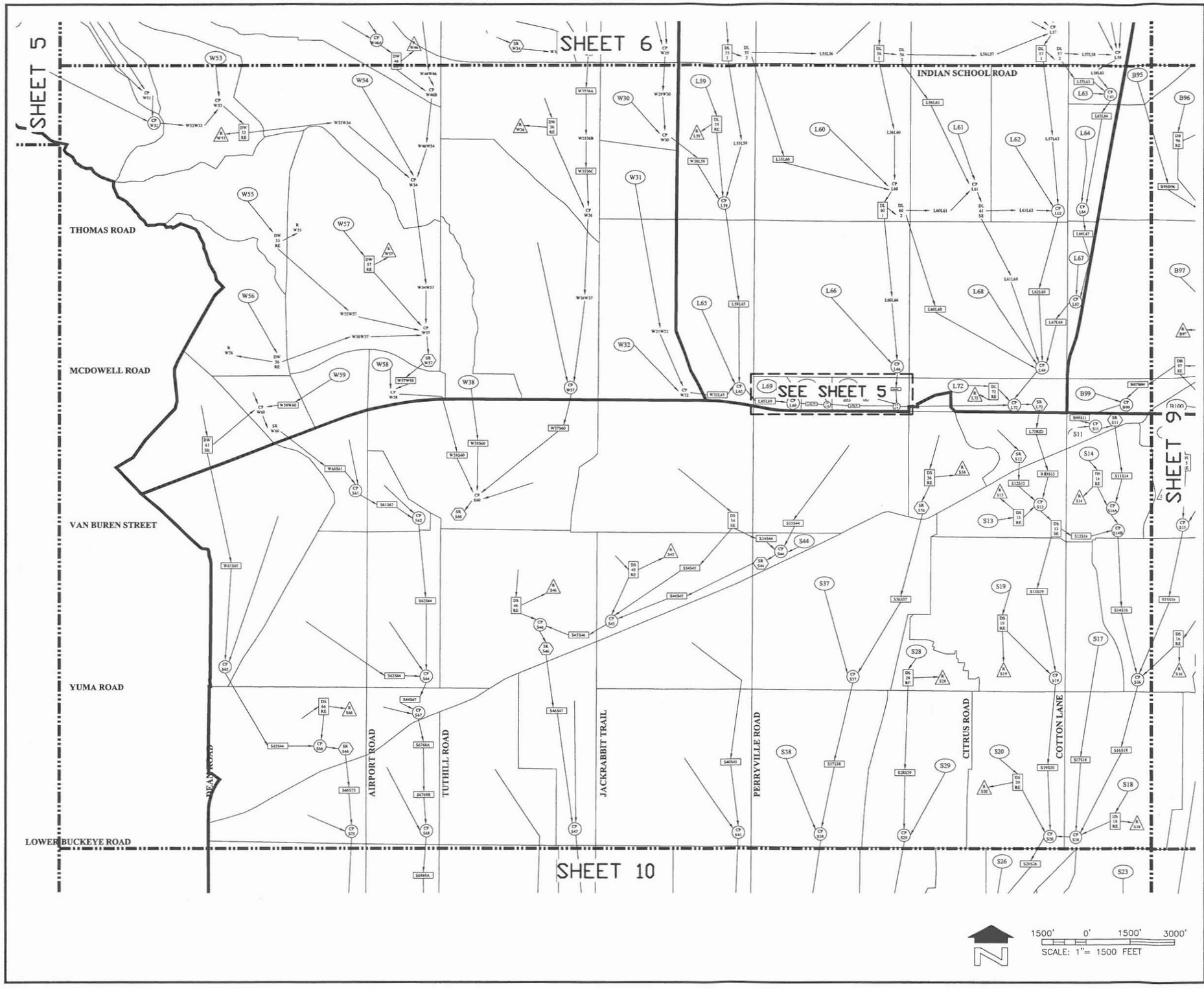

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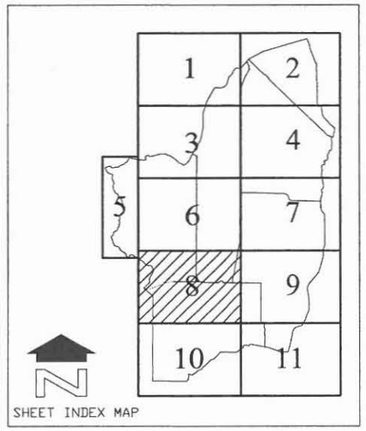

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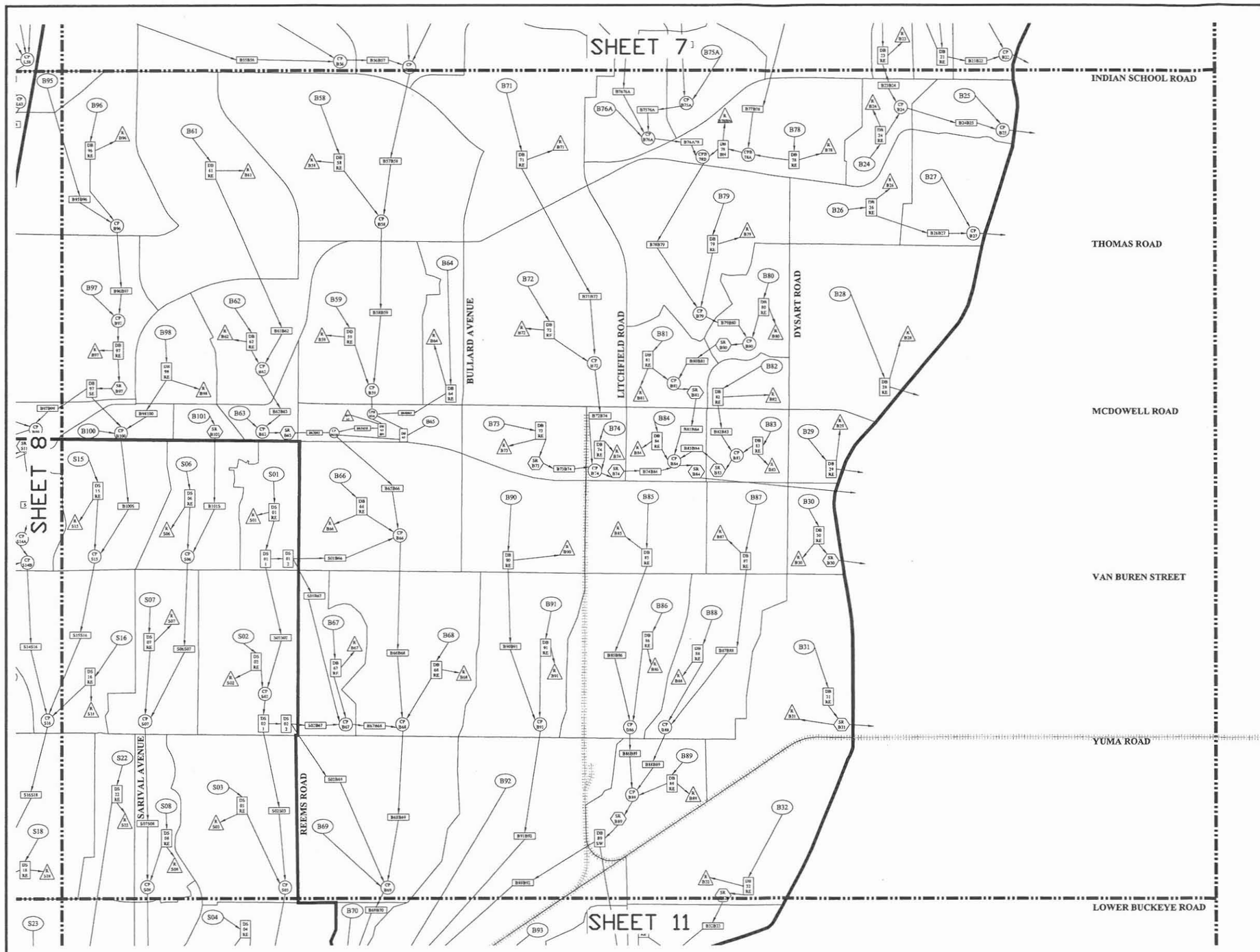
SHEET 8 OF 12



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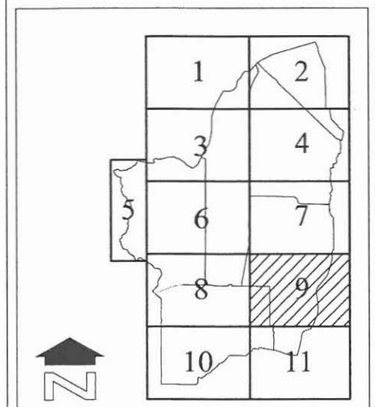

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SHEET 9 OF 12

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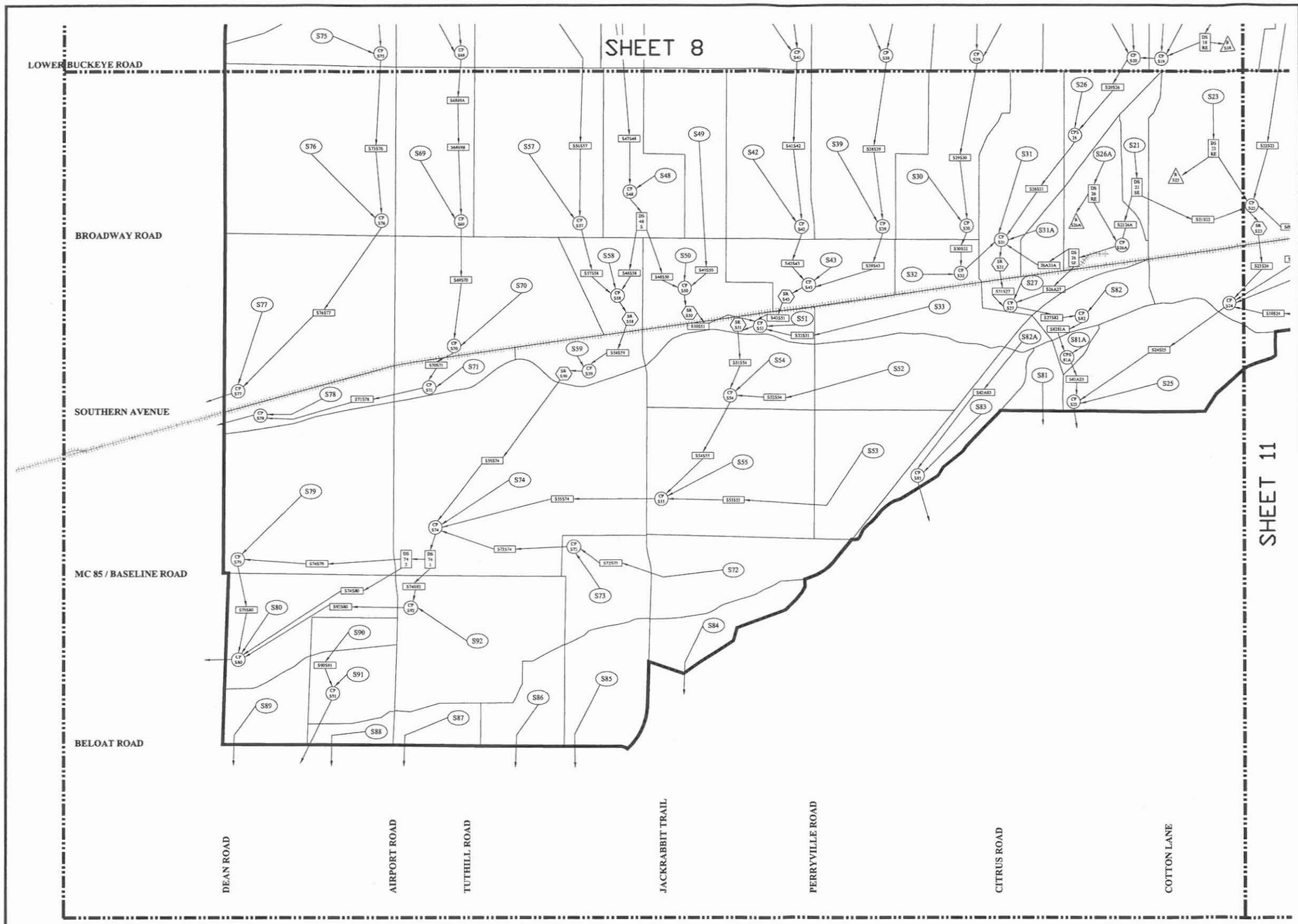
1500' 0' 1500' 3000'

SCALE: 1"= 1500 FEET



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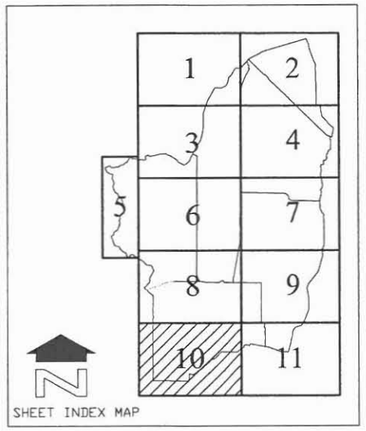

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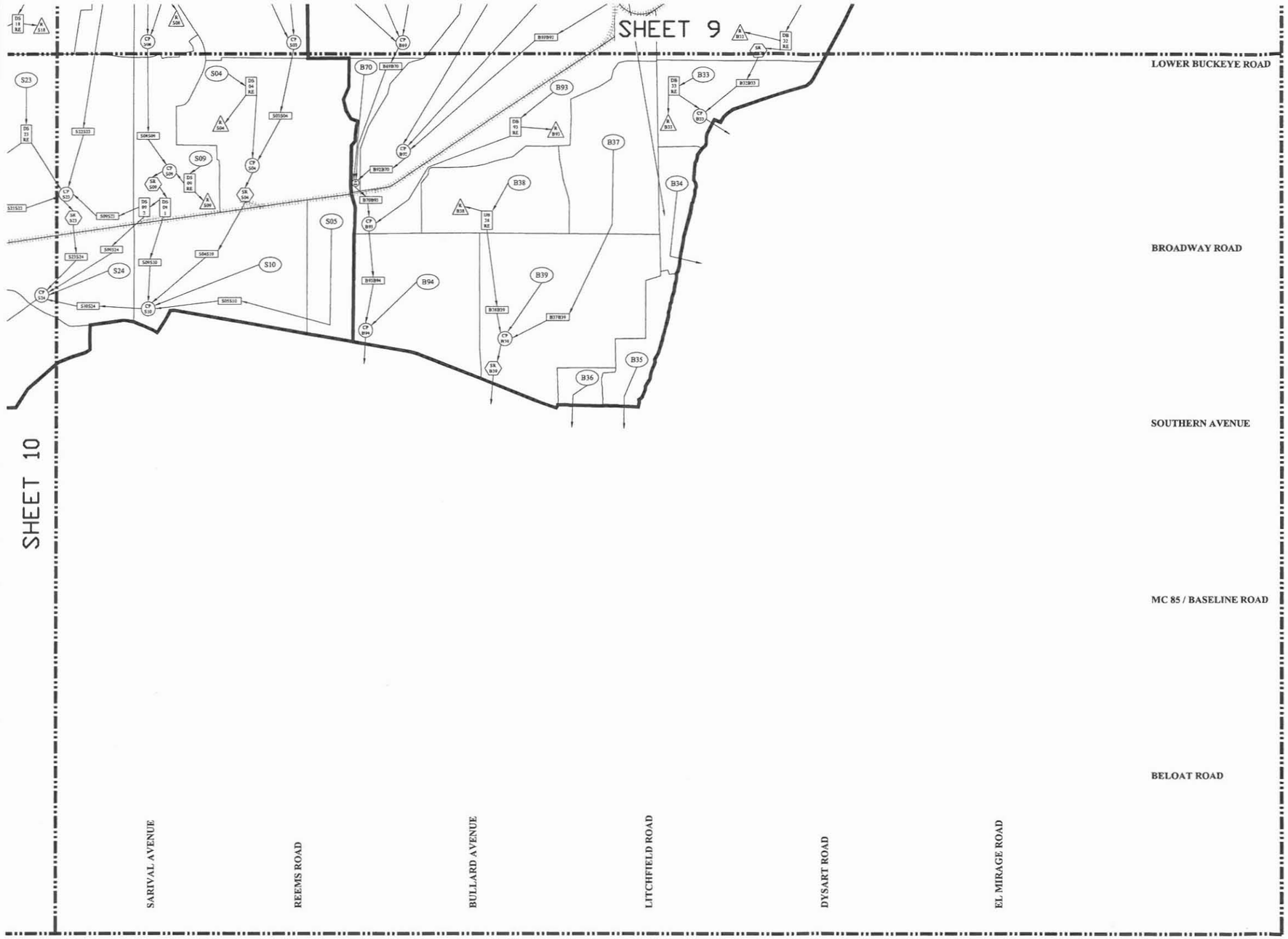

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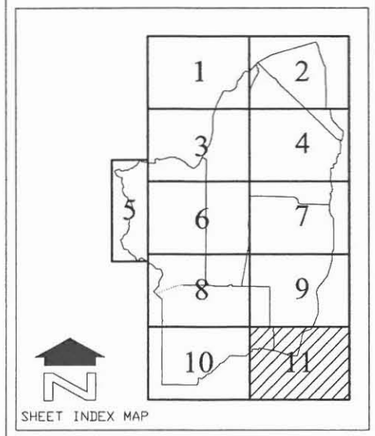

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